This study was conducted in response to the growing concern about the lack of U.S. students majoring in STEM fields and pursuing STEM careers (NSF, 2013). In order for the U.S to compete in a global economy that is increasingly technologically-based, a skilled STEM workforce is a necessity (National Academies, 2010). Understanding the factors that encourage confidence in science and intent to pursue science-related careers remains a national mandate. Using data from a nationally representative sample of 21,440 students from 940 schools, the High School Longitudinal Study of 2009 (HSLS:09), this study provides insight into the factors that predict science self-efficacy and STEM career intent. Guided by Lent, Brown & Hackett’s (1994) Social Cognitive Career Theory (SCCT), both student-level and school-level factors were examined. The findings indicate that the personal inputs of being African American, female, and having a science identity predict both science self-efficacy and STEM career intent. Participating in no extracurricular informal learning experiences predicts both science self-efficacy and STEM career intent, while participating in more than one extracurricular learning experience only predicts self-efficacy. Background contextual affordances such as socioeconomic status had no relationship to either science self-efficacy or STEM career intent. Parents who were very confident and somewhat confident in helping their child with science homework predicted science self-efficacy but showed no relationship to STEM career intent. None of the school-level variables predicted science self-efficacy, but the percentage of students on free/reduced lunch, students in schools located in the city, and students in Catholic schools predicted STEM career intent. Finally, the relationship between contextual affordances (SES and parental support) and
science self-efficacy and STEM career intent did vary by sex for both outcome variables regarding socioeconomic status, but not regarding parental support.

Several implications arose from this study. First, science identity is a very useful construct that can be used to further examine science self-efficacy and STEM career intent. Based on this study’s findings, educators and policy makers should seek ways to help foster student science identity. Second, efforts to encourage girls in STEM have not been successful on a large scale and more strategies need to be explored. Third, this study makes the case for continued involvement in informal science experiences that provide students a chance to explore science at their own pace in a non-evaluative environment. Finally, while race/ethnicity has traditionally been a predictor of science self-efficacy and STEM career intent, this study suggests that there may be subcategories within race/ethnicity such as cultural perspective and additional constructs such as critical race theories that may shed light on the nuances at play, especially in the case of students who self-identify as African American.
Predicting 9th Graders’ Science Self-efficacy and STEM Career Intent: A Multilevel Approach

by
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A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the degree of Doctor of Education

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DEDICATION

To my mom Mrs. Alyse H. Wagstaff.
BIOGRAPHY

Iris R. Wagstaff is a native of Goldsboro, NC. She earned her B.S. degree in Chemistry from UNC-Greensboro in 1993 and her M.S. degree in Chemistry from NC A&T State University in 1996. Her master’s thesis examined Characterization and Stereochemical Analysis of a Series of Beta-Keto Esters by 2D NMR. From 1995 to 2007, Iris was a research scientist for Dow Chemical Company in Spring House, PA, where she led analytical research teams, reverse-engineered competitive products and developed in-house analytical capabilities. While a scientist at heart, Iris has over 20 years of STEM outreach experience in the community and has developed informal science programs, coached science teachers, mentored, tutored, and spoken at schools and community organizations about science careers. In 2010, Iris entered the Ph.D. program in Educational Research and Policy Analysis. While at NCSU, Iris has mentored and tutored students in the Upward Bound program, TRIO, the Alliance for Graduate Education Participation (AGEP), the College of Education’s Student Undergraduate Research Experience (SURE) program and taught science for the Math, Science, and Education Network (MSEN) as well as at the Science House. In 2011 she was awarded the AGEP fellowship for service and in 2012 was inducted into the Phi Kappa Phi National Honor Society for students with a GPA of 4.0 or higher. In 2013 she was awarded the Augustus M. Witherspoon Graduate Scholarship for research and service, and also in that year, she co-developed Exploring Chemistry Innovations Through Engagement (EXCITE). She was also selected to present at the 2013 and 2014 AERA annual conferences.
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# TABLE OF CONTENTS

LIST OF TABLES ......................................................................................................................... viii

LIST OF FIGURES ..................................................................................................................... ix

CHAPTER I: INTRODUCTION ....................................................................................................... 1

U.S. STEM Degrees ..................................................................................................................... 4

U.S. Performance in STEM .......................................................................................................... 6

Underrepresented Groups (URGs) in STEM ............................................................................... 10

Statement of the Problem ........................................................................................................... 14

Science Self-Efficacy .................................................................................................................. 16

Purpose ...................................................................................................................................... 17

Research Questions ..................................................................................................................... 17

Conceptual Framework ............................................................................................................... 19

High School Longitudinal Study (HSLS:09) .............................................................................. 19

Research Design .......................................................................................................................... 20

Significance of Study ................................................................................................................... 20

Limitations .................................................................................................................................. 21

Key Definitions ............................................................................................................................. 22

Chapter Summary and Overview of Study .................................................................................. 22

CHAPTER II: LITERATURE REVIEW ........................................................................................... 24

Self-Efficacy ................................................................................................................................. 26

Science Self-Efficacy ................................................................................................................... 27

STEM Career Intent .................................................................................................................... 28

Research Questions ..................................................................................................................... 31

Theoretical Framework ............................................................................................................... 32

Person Factors .............................................................................................................................. 38

Sex .............................................................................................................................................. 38

Race, Ethnic Identity, and Culture .............................................................................................. 39

Career Choice (STEM Career Intent) ......................................................................................... 43
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background or Contextual Factors</td>
<td>46</td>
</tr>
<tr>
<td>Family and Parental Support</td>
<td>49</td>
</tr>
<tr>
<td>Learning Experiences</td>
<td>52</td>
</tr>
<tr>
<td>Conclusion</td>
<td>54</td>
</tr>
<tr>
<td>Chapter Summary</td>
<td>56</td>
</tr>
<tr>
<td><strong>CHAPTER III: METHODOLOGY</strong></td>
<td>57</td>
</tr>
<tr>
<td>Data Collection</td>
<td>58</td>
</tr>
<tr>
<td>Source</td>
<td>58</td>
</tr>
<tr>
<td>Data Collection</td>
<td>59</td>
</tr>
<tr>
<td>Sampling Procedures</td>
<td>60</td>
</tr>
<tr>
<td>Selection of School Sample</td>
<td>62</td>
</tr>
<tr>
<td>Sample</td>
<td>65</td>
</tr>
<tr>
<td>School and Student Demographics</td>
<td>65</td>
</tr>
<tr>
<td>Variables</td>
<td>71</td>
</tr>
<tr>
<td>Outcome Variables</td>
<td>73</td>
</tr>
<tr>
<td>Predictor Variables (Student level data)</td>
<td>75</td>
</tr>
<tr>
<td>Predictor Variables (School Level Data)</td>
<td>80</td>
</tr>
<tr>
<td>Data Management</td>
<td>82</td>
</tr>
<tr>
<td>Analysis</td>
<td>82</td>
</tr>
<tr>
<td>Missing Value Analysis and Multiple Imputation</td>
<td>82</td>
</tr>
<tr>
<td>Multicollinearity Diagnostics</td>
<td>83</td>
</tr>
<tr>
<td>Hierarchical Linear Modeling</td>
<td>84</td>
</tr>
<tr>
<td>Model Specification</td>
<td>86</td>
</tr>
<tr>
<td>Science Self-Efficacy Fully Unconditional Model (Null)</td>
<td>86</td>
</tr>
<tr>
<td>Science Self-Efficacy Random Effects Model</td>
<td>87</td>
</tr>
<tr>
<td>Science Self-Efficacy Random Effects Model with Interaction</td>
<td>87</td>
</tr>
<tr>
<td>Science Self-Efficacy Intercepts-As-Outcomes Model</td>
<td>88</td>
</tr>
<tr>
<td>STEM Career Intent Fully Unconditional Model (Null)</td>
<td>90</td>
</tr>
<tr>
<td>STEM Career Intent – Random Effects Model</td>
<td>90</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>STEM Career Intent Intercepts as Slopes Model</td>
<td>91</td>
</tr>
<tr>
<td>Chapter Summary</td>
<td>92</td>
</tr>
<tr>
<td><strong>CHAPTER IV: RESULTS</strong></td>
<td>93</td>
</tr>
<tr>
<td>Research Questions</td>
<td>93</td>
</tr>
<tr>
<td>Descriptive Statistics</td>
<td>94</td>
</tr>
<tr>
<td>Level 1 Variables (Student)</td>
<td>96</td>
</tr>
<tr>
<td>Level 2 Variables (School)</td>
<td>100</td>
</tr>
<tr>
<td>Predicting Student Science Self-Efficacy</td>
<td>102</td>
</tr>
<tr>
<td>Null Model</td>
<td>105</td>
</tr>
<tr>
<td>Random Effects Model</td>
<td>105</td>
</tr>
<tr>
<td>Intercepts-as-Outcomes Model</td>
<td>107</td>
</tr>
<tr>
<td>Predicting STEM Career Intent by Age 30</td>
<td>108</td>
</tr>
<tr>
<td>Random Effects Model</td>
<td>112</td>
</tr>
<tr>
<td>Intercepts-as-Outcomes Model</td>
<td>113</td>
</tr>
<tr>
<td><strong>CHAPTER V: CONCLUSIONS AND DISCUSSION</strong></td>
<td>115</td>
</tr>
<tr>
<td>Key Findings</td>
<td>115</td>
</tr>
<tr>
<td>Predicting Science Self-Efficacy</td>
<td>118</td>
</tr>
<tr>
<td>Predicting STEM Career Intent</td>
<td>119</td>
</tr>
<tr>
<td>Theoretical Implications</td>
<td>122</td>
</tr>
<tr>
<td>Race, Sex, Identity, and Informal Science</td>
<td>122</td>
</tr>
<tr>
<td>School Characteristics</td>
<td>125</td>
</tr>
<tr>
<td>Practical Implications</td>
<td>127</td>
</tr>
<tr>
<td>Limitations</td>
<td>128</td>
</tr>
<tr>
<td>Future Directions for Research</td>
<td>129</td>
</tr>
<tr>
<td>Summary</td>
<td>130</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>132</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1 Variables Used from HSLS:09 ................................................................. 72
Table 2 Descriptive Statistics for Student Level Variables-Student Weighted ............ 95
Table 3 Descriptive Statistics for School Level Variables – Weighted ......................... 96
Table 4 Student level and School Level Predictors of Student Science Self-Efficacy - Weighted ........................................................................................................ 103
Table 5 Student level and School Level Predictors of STEM Career Intent-Weighted (β Coefficients) .................................................................................................. 109
Table 6 Student level and School Predictors of STEM Career Intent-Weighted (Odds Ratios) ........................................................................................................ 111
Table 7 Protocol for Odds Ratio Interpretation .......................................................... 112
Table 8 Summary of Key Findings ............................................................................. 116
LIST OF FIGURES

Figure 1. Diagram of Model 1 Variables ................................................................. 36
Figure 2. Model 2 Logistic Regression Variables .................................................... 37
Figure 3. Diagram of first stage sampling .............................................................. 61
Figure 4. Diagram of Sampling second stage sampling ........................................... 62
Figure 5. Diagram of sample clustering ................................................................. 85
CHAPTER I: INTRODUCTION

The Soviet Union launched the first satellite (Sputnik) into space in 1957 catching the United States by surprise (Collins, 2007). This action propelled the U.S. into recruiting scientists, mathematicians and engineers from all areas of the country to ignite our space exploration program. The “Sputnik Challenge” not only birthed the United States’ vested interest in being a Cold War superpower, but it also led to a period of scientific inquiry and innovation that has gone unmatched for decades. In 1983 the National Commission on Excellence in Education issued a report entitled A Nation at Risk: The Imperative for Educational Reform. This report was commissioned in response to a crisis in education that exhibited low graduation rates, low student performance across subjects, and an impending threat of losing the scientific and technological gains obtained during the 1950s (The National Commission on Excellence in Education, 1983). The report states:

Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world…. the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people. (p. 9)

The members of the committee were charged with assessing the quality of teaching and learning in the United States with a specific focus on high school education. Among the recommendations that resulted from the report was the standardization of science and math curricula in order to help better prepare students for future technical careers. In 2013 the country is facing yet another “Sputnik” moment.
Over the last decade there has been growing concern about the lack of U.S. citizens majoring in the Science, Technology, Engineering and Mathematics (STEM) fields. This concern has reached to the highest levels of the national political agenda. In his February 12, 2013 State of the Union Address, President Barack Obama called for one million more STEM graduates over the next decade (Obama, 2013). The president demonstrated his commitment to STEM education during the address by announcing an increase in federal funding (to $3 billion dollars) for 2013. His announcement was on the heels of his summer 2012 mandate of 100,000 more science teachers over the next decade. The president’s concerns about the growing demand for STEM professionals are supported by Carnevale, Smith, and Melton’s (2011) estimate that there will be “2.4 million job vacancies in STEM between 2008 and 2018”. Will the U.S. be prepared to meet this demand?

According to the Office of Naval Research (2010), interest in science and engineering related subjects and degrees remains low. The study reports that only one third of U.S. eighth graders are interested in STEM majors and a little more than 5% of high school seniors will get a bachelor’s degree in a STEM field. Compared to other nations, the U.S. is ranked 27th out of 29 for the rate of STEM bachelor’s degrees awarded in developed countries. Furthermore, “Only 6% of U.S. undergraduates major in engineering compared with 12% in Europe, 20% in Singapore, and 40% in China” (National Academies, 2007). In addition to low entry rates for U.S. students in STEM, we are also seeing high attrition rates. Less than half of U.S. undergraduates that declare intent to major in a STEM field actually complete their degree (National Science Board, 2010). In 2007, the National Academies’ report, The Gathering Storm, chronicled the shortage of U.S. STEM workers and related concern for
future academic and economic sustainability resulting from this projected shortage (National Academy of Sciences, 2007). This concern was reiterated three years later in a follow-up report when it was evident that significant strides had not been made in attempts to attract native born students to the STEM pipeline (National Academy of Sciences, 2010). In a study conducted by the Georgetown University Center on Education and the Workforce, Carnevale et al. state:

What is really at stake in the current debate over the existence of quantifiable STEM shortages is an important question regarding a national strategy for sustaining economic innovation in the United States at a time when science, technology, innovation, and related work in STEM occupations have become more integrated globally.

Additionally, during the past two decades we have seen significant changes in the U.S. STEM workforce. Years ago, the workforce was predominantly white, male and made up of U.S. citizens. However, with the lack of U.S. citizens majoring in STEM careers, the U.S. has been relying on foreign talent, mainly from India and China to populate the STEM workforce (The National Academies, 2010). While the science and engineering workforce is the fastest growing sector of the U.S. labor force, it still only accounts for 5% of the nation’s total workforce and non-U.S. citizens account for almost all of the growth in STEM doctorates (Hira, 2010; The National Academies, 2010). The U.S. cannot continue to rely on foreign talent since foreign born students plan to go back to their native countries, leaving a gap in the STEM talent pool. Moreover, with the current American STEM work force, we cannot continue to compete in a global economy that is increasingly more scientifically and
technology-based without skilled domestic talent (National Academy of Sciences, 2007). These developments and trends continue to be of growing interest in the science education and policy communities. Of specific concern is how to determine innovative and effective ways to promote interest in STEM at early ages with hopes of leveraging that interest to encourage more American youth to pursue STEM careers.

**U.S. STEM Degrees**

STEM degree completion is vital to the U.S.’s competitiveness (National Academies, 2007), yet relatively few students obtain a STEM bachelor’s degree. Reports suggest that the STEM education pipeline narrows quickly (National Academies, 2010). In 1997 there were around 3.8 million 9th graders in the United States. In 2001, about 2.7 million students graduated from high school in the same year and almost 1.7 million students enrolled in two- or four-year colleges. However, by 2007 only about 233,000 students earned a STEM bachelor’s degree (National Science Board, 2010).

Finding ways to keep students in the pipeline at all levels continues to be a challenge. Over the last decade, community colleges have been viewed as a bridge to four-universities with regards to STEM degrees. Efforts by community colleges to support the growing demand for STEM workers have increased significantly (Starobin & Laaan, 2010). The lack of STEM workers in the U.S. has been well-documented and is the rationale for the many initiatives at the federal, state and local levels to bring more native citizens into the pipeline. In fact, most community colleges are aligned with local job market needs and tailor their programs accordingly (Starobin & Laaan, 2010). Carnevale, Smith and Melton’s (2011) study is a pivotal indicator for projected STEM degree and market demand trends. The
report suggests that 65% of STEM jobs will require at least a bachelor’s degree. Carnevale et al. examined trends in all areas of STEM such as the computer industry, pharmaceuticals and engineering in order to develop projections. The other 35%, however, is the focus of an article by Mangan (2013) on the role that community colleges can play in increasing America’s STEM talent pool. Mangan cites STEM: Science Technology Engineering Mathematics as a rationale to continue to establish STEM transfer programs so that community colleges are aligned with the projected STEM labor market. Mangan contends that better advertising of STEM programs and resources about STEM programs need to be in place to help facilitate STEM transfer from community colleges to four-universities. Support mechanisms in place to aid students with coursework, career counseling, tutoring and a clear understanding of the transfer process also have to be present. Lastly, Mangan states that more synergy or standardization of the number of credit hours that four-universities will accept from community colleges throughout the state is necessary to foster STEM transfer from community colleges to 4-year colleges.

Metrics on U.S. graduate degrees in STEM fields can be good indicators of projected entry into STEM careers. According to the National Science Foundation survey of earned doctorates in the United States from the years 1991 – 2011 (NSF, 2012), doctorates in science and engineering fields, particularly in life sciences, represented a significant number of doctorates awarded. Science and engineering doctorates accounted for 74% of all doctorates awarded in 2011. However, foreign-born students continue to represent the largest increases in STEM degree completion, the majority of engineering degrees in 2011, and over 40% in the physical sciences. These results suggest that while we are seeing some
gains in STEM degree completion overall, native-born students completing these degrees continues to lag significantly behind temporary visa holders.

**U.S. Performance in STEM**

There are three main assessments that give a comprehensive picture of how U.S students are performing in critical areas such as math and science and how they compare to their counterparts around the world. Those tests are NAEP, PISA and TIMSS. According to the latest report of Science and Engineering Indicators (National Science Foundation, 2012), U.S. students are lagging behind other developed nations in math and science.

The National Assessment of Educational Progress (NAEP) is the longest running and largest national assessment of student competencies in various subjects that include math, science and reading (U.S. Department of Education, 2013). It is administered periodically at grades 4, 8 and 12. The NAEP does not provide results on individual students or schools. It does, however, provide results for populations of students (various grade levels) and groups of interest within these populations (females, minorities). Since the NAEP is administered uniformly among all states, it is viewed as a common metric for U.S. overall student performance and is often referred to as the nations “report card.” The latest NAEP was conducted in 2011 on a nationally representative sample of 122,000 8th graders. The students were assessed in physical science, life science, earth, and space sciences. The scores are reported on an average scale of 0 – 300 at three levels: basic–partial mastery, proficient–solid performance and advanced–superior performance. Eighth grade performance improved only slightly from 2009, increasing from 150 to 152 (NCES, 2012). Sixty-five percent of eighth-graders performed at or above basic in 2011, 32% performed at or above proficient,
and only 2% of students performed at the advanced level. Racial/ethnic groups made slight advances with Black students scoring 3 points higher than 2009, and Hispanic students scoring 5 points higher. However, there were no significant changes for Asian/Pacific Island or American Indian/Native Hawaiian students. While White students continue to score higher than all other groups, the racial gap narrowed compared to 2009 with Asian/Pacific Island students almost even with their White counterparts (159 to 163).

There continued to be gaps between the performance of public school students and private school students with the latter scoring 12 points higher (NCES, 2012). Additional trends from the math tests revealed that students across income levels scored higher in 2009 and that there was an increase in students doing hands-on projects in class; additionally, two-thirds of the students reported that they work together on science projects at least weekly. Finally, students who did science-related activities outside of class scored higher than students who reported that they did not engage in extra-curricular science activities. This finding is interesting and suggests that participating in science activities out of school may be beneficial to overall performance.

The 2011 math test assessed a representative sample of 4th and 8th grade students from 21 urban districts around the country (NCES, 2011). Between 1,000 and 2,700 students from each district were assessed at both grade levels. Students at both levels were assessed in five areas: 1) number properties and operations, 2) measurement, 3) geometry, 4) data analysis, statistics and probability, and 5) algebra. The questions are rated at three complexity levels: low, moderate, and high. Scores are reported on a scale of 0 – 500 at the same three levels as the science test (basic, proficient, advanced). Overall, scores were higher than 2009 for four
districts at grade level 4 and for eight districts at grade level 8. Public school students scored higher at both grade levels than in 2009. Three districts stood out: Austin, TX; Charlotte, NC; and Hillsborough County, FL. All scored higher than the national average. The districts showed a range of skill proficiency from 34% in Detroit to 88% in Charlotte (NCES, 2011). Finally, this report suggests that it is important to consider demographic differences when comparing urban districts to the rest of the nation. For example, nationally, White students outnumber combined Black and Hispanic populations, but in this study, the opposite is true. Additionally, urban districts tend to have more students on free or reduced lunch, which is an indicator of SES (74% compared to 52%).

In additional to national assessments of student performance in critical areas such as math, science, and reading, there are two international metrics: the PISA and TIMSS. The Program for International Student Assessment (PISA) is an international assessment that measures 15-year-old students' reading, mathematics, and science literacy (U.S. Department of Education, 2013). It also measures problem-solving and other functional skills that are desired as high school students prepare for post-secondary education. The PISA is administered by the Organization for Economic Cooperation and Development (OECD), an intergovernmental organization of industrialized countries and is conducted by the U.S. Department of Education’s National Center for Education Statistics (NCES). PISA was first administered in 2000 and is conducted every three years. The most recent assessment was administered in 2012 and the results indicated that the U.S. ranked 26th in math and 21st in science, and that U.S. 15-year-olds continue to produce flat scores in science and math while other countries improve (Kelly, Xie, Nord, Jenkins, Chen, & Kastberg, 2013). The results
also indicate that U.S. students ranked below average in math among the world’s most-developed countries, and close to average in science. In the United States, 9% of 15-year-old students scored at proficiency level 5 or above, which was lower than the OECD average of 13%. In the U.S., 18% of 15-year-old students scored below level 2, which was not significantly different from the OECD average of 18%. These results suggest that the U.S. has not made substantial progress in math and science compared to other developed nations.

The second international assessment of U.S. students that is often reported is the Trends in International Mathematics and Science Study (TIMSS). It provides data on the math and science achievement of U.S. 4th and 8th grade students compared to that of students in other countries (U.S. Department of Education, 2013). The first study was in 1995, and it is conducted every four years. Generally, about 60 countries participate in the study. The latest TIMSS data were collected in 2011. Highlights from the 2011 test revealed that at grade 4, the U.S. scored 541, which was higher than the TIMSS average score of 500 (Provasnik, Kastberg, Ferraro, Lemanski, Roey, & Jenkins, 2012). Also at grade 4, the United States was among the top 15 education systems in math and scored higher on average than 42 other nations. Out of the states that participated in the study, North Carolina stood out by scoring above both the TIMSS scale average and the U.S. national average in math. Additionally, U.S. students have continued to improve their performance in math since 1995, even though the improvements have been small. At the 8th grade math level, again the United States scored slightly higher than the TIMSS average (509 compared to 500). The United States was among the top 24 education systems at grade 8 and scored higher on average than 32 other nations. Several states stood out at this grade level: Massachusetts,
Minnesota, North Carolina, and Indiana all of which scored above both the TIMSS average and U.S. national average in math (Provasnik, et al., 2012).

The scores for U.S. students in science at grade level 4 were similar to that for math with the U.S. scoring 544 compared to a score of 500 for the TIMSS average. At this grade level, U.S. students were among the top 10 education systems and scored higher than 47 other countries in science. Again, North Carolina stood out along with Florida, scoring higher that the TIMSS average. At grade 8, U.S. students scored only slightly higher than the TIMSS average (525 compared to 500). However, there was no significant increase in scores for U.S. students since the test was first administered in 1995. This fact is concerning and suggests that while we are seeing some slight strides in math, the overall trends for science over the last 18 years do not show significant improvements in science literacy. Overall, these national and international assessments of U.S. students in math and science suggest that while we are seeing slight strides over previous years, the United States still lags other developed nations with comparable resources, which indicates that science educators and policy makers need to address this low performance in order for the United States to compete in a global economy that relies on science and engineering industries.

**Underrepresented Groups (URGs) in STEM**

Over the past few decades the race/ethnic profile of America has changed dramatically. The minority population is increasing at a higher rate than the White majority in the United States. According to the 2010 census, Hispanics/Latinos(as) are the fastest-growing and largest ethnic minority group in the United States and represent 16% of the population, while Blacks represent 12% (U.S. Department of Commerce, Census Bureau,
As of 2008, minorities accounted for one third of the population and are expected to be the majority by 2042. Ethnic and racial minority adolescents are projected to account for 62% of school-aged children by 2050 (U.S. Department of Commerce, Census Bureau, 2008). By 2025 the U.S. population is expected to be 21% Hispanics, 58% White, 12% Black, 6% Asian, 1% American Indian, 1% Pacific Islander, and 2% other (U.S. Department of Commerce, Census Bureau 2008). These projections show that students in our schools are becoming more and more diverse.

While it is evident that we are seeing dramatic increases in the minority population in the U.S., minority representation in STEM fields is very low and does not mirror the current and projected demographic shifts. According to the National Science Foundation, groups considered to be underrepresented in STEM are women, Blacks, Hispanics/Latinos(as), Native Americans, Pacific Islanders and Alaskan natives (NSF, 2013). Women, who are the largest group that is underrepresented in STEM, account for about 50% of the population but only 19% of science and engineering fields (NSF, 2013). The numbers for ethnic minorities are worse. While Blacks account for 12% of the population, they only represent 3% of science and engineering fields and Hispanics represent 16% of the population and only 4% of science and engineering fields (National Science Foundation, 2013). Diversifying the STEM workforce will allow previously disenfranchised groups not only the chance to participate in solving global problems, but also a chance to improve their economic status (National Academies, 2010). Diversity is not only good for business, but it is good for the country. Diversity brings different approaches and lenses to solving the problems that we face as a nation (National Academies, 2010). Despite these possible advantages to having a diverse
STEM workforce, there are several reasons why underrepresented groups (URGs) do not pursue STEM careers. Among them are lack of access to quality science education, negative stereotypes and stereotype threat, discrimination, poor prior performance in school, lack of support, and lack of role models and mentors (National Academies, 2010).

Another explanation for the low representation of women and minorities in STEM is the lack of congruency between school science and students’ lived experiences (Costa, 1995; Phelan, 1991). Science is a culture, and the failure of many science education reform initiatives and policies to consider sociocultural aspects contributes to the underrepresentation of females and ethnic minorities in the STEM pipeline and careers (Russell & Atwater, 2005). Science education reforms that foster a sense of science identity for diverse student populations have proven to be a fruitful area of research and the science identity construct may shed light on the STEM career choice process for URGs (Carlone & Johnson, 2007).

Finally, the lack of science self-efficacy plays a significant role in the STEM career choice of underrepresented groups (Navarro, Flores, & Worthington, 2007) and is the focus of this study. Students with high science self-efficacy tend to perform better academically and are more likely to translate that confidence into long-term goals of majoring in STEM fields and becoming employed in STEM industries.

One of the foremost authorities on increasing minority participation in STEM at the collegiate and graduate levels is Dr. Freeman Hrabowski, III. He has been the President of the University of Maryland at Baltimore County (UMBC) since 1992. UMBC is a university that focuses on science and math related degrees. Dr. Hrabowski’s research and publications
focus on math and science education and preparing students for STEM graduate degrees and STEM careers. Because of his expertise, he was asked to chair the 2010 National Academies committee report “Expanding Underrepresented Minority Participation: America’s Science and Technology Talent at the Crossroads.” The report chronicles the failures over the years of the educational system to attract minorities to science and engineering fields. Some of these failures include the lack of support systems at every level of the pipeline and making URGs feel inadequate and less intelligent. In addition to the National Academies report, Dr. Hrabowski has developed strategies to increase minority representation in STEM based on research and evaluation of his programs at UMBC. Some of Dr. Hraboski’s recommendations include establishing strong study habits as well as employing study groups and university-led initiatives to build stronger relationships between faculty and minority students in STEM majors.

Lack of social and academic integration is a major problem for minorities, especially on predominantly White campuses (Maton, Pollard, McDougall, Weise, & Hrabowski, 2012). Moreover, faculty tend to have preconceived notions that minority students “do not have what it takes” to succeed in STEM and therefore do not require the same affordances that majority students receive. UMBC has been a model for the last 15 years for increasing minority participation in STEM at the college level, especially among Black males. Another recommendation includes providing more hands-on research opportunities on campus which will facilitate a more sophisticated understanding of concepts learning in class. Maton, Hrabowski, and Pollard (2011) report that Black males at UMBC are five times more likely than their counterparts at other schools to enter and complete STEM degrees. Because ethnic
minorities and females have historically been discouraged from pursuing science and engineering careers, the mechanisms suggested will provide a foundation and roadmap for engaging more underrepresented minority students to and through the STEM pipeline.

Statement of the Problem

With the election of President Barack Obama, significantly increasing the American STEM workforce, as well as creating a cadre of well trained and qualified STEM teachers has become a national mandate. The low numbers of American students majoring in STEM fields is of great concern to science educators and policy makers (National Academies, 2007, 2010). The science and engineering industry is vital to the United States’ goal of remaining a world super power and maintaining its dominance in the global economy. Additionally, scientific and technical talent is needed to solve the nation’s problems. According to a report from the Census Bureau (2011), foreign-born Americans are earning STEM degrees in disproportionately large numbers compared to the native-born U.S. population. The report also states that over 20% of bachelor’s holders who earned their degrees in what the Census classifies as "science and engineering fields" are foreign-born. Of these fields, the only ones in which native-born students lead their foreign-born counterparts are psychology, social sciences, and multidisciplinary sciences. This suggests that the United States is not preparing its students as adequately as some other nations. According to the OECD’s 2011 Education rankings, the United States is average among OECD countries in mathematics and below average in science. One explanation for this trend is culture. Many countries that send significant numbers of students to the United States to pursue education place a high value on science, engineering, and math training. According to the Census, 57% of these students
come from Asia, with Chinese and Indian students comprising the majority. Furthermore, foreign-born students are incentivized to study science and engineering due to extensions and concessions in VISA policies for STEM majors through a program called "optional practical training." (OECD, 2011, p.13).

A popular explanation for the lack of U.S. students majoring in STEM is that they cannot “see” themselves in STEM or relate to science (Carlone & Johnson, 2007). This lack of a science identity affects their interest in science and, in turn, their career choice goals. This had led science educators and policy makers to focus on engaging students in STEM through hands-on, inquiry-based lessons in school as well as through informal science programs that give students a chance to explore science at their own pace. These strategies have been in place with the hope of increasing interest in science and ultimately STEM career choice. However, with the emergence of many of these outreach programs and science and math pedagogical reforms, we are still seeing low numbers of American students majoring in STEM fields.

According to the Department of Commerce (2011), the number of jobs in science and engineering grew at three times the rate of those in other fields over the last 10 years. Educating native-born American students to be competitive in the STEM labor force requires those students to first complete STEM degrees. However, many U.S. STEM graduates are diverted away from the pipeline due to low academic performance and into jobs in science the business and healthcare fields (OECD, 2011). Underrepresentation of women and ethnic minorities exacerbates this problem because the U.S. needs to take advantage of all of its resources and human capital in order to remain competitive globally (National Academies,
The U.S. needs a strong technical domestic workforce. Researchers, practitioners, and policy makers must understand the factors that attract native students, especially those that are underrepresented and traditionally discouraged from STEM; this is imperative for academic excellence, economic stability and national security (National Academy of Science, 2007). The country will need to rely on those with the set of skills developed through STEM disciplines to solve the challenging problems outlined in the National Academies Engineering Grand Challenges (National Academies, 2008), such as protecting our food supply, determining alternative energy sources, and cyber security.

While there is some literature on attracting students to the STEM pipeline at the college level, improving science self-efficacy and fostering STEM career intent of high school students, specifically underrepresented groups, remains understudied as a means of increasing the number of U.S. citizens employed in STEM professions (National Academies, 2010). This study seeks to fill a gap in the literature by examining a nationally representative sample of 9th graders’ science self-efficacy and STEM career intent and factors that predict these constructs to provide insights to science educators and policy makers about how to foster these constructs that are linked to increasing and diversifying the STEM pipeline.

**Science Self-Efficacy**

Science self-efficacy is one construct that has been shown to influence interest in STEM and STEM career intent. It refers to one’s confidence or belief in their ability regarding science related activities (Britner & Pajares, 2006). Students who have higher science self-efficacy tend to have greater interest in science and are more likely to pursue science related careers compared to students with low science self-efficacy (Britner &
Robert W. Lent has published most of the seminal work in the area of science self-efficacy as it relates to predicting STEM career choice and persistence in STEM majors (Lent, Brown, Sheu, Schmidt, Brenner & Gloster, 2005; Lent, Sheu, Singley, Schmidt, & Gloster, 2008; Lent, Lopez & Sheu, 2011; Lent, Miller, Smith, Watford, Lim, Hui, Morrison, Wilkins & Williams, 2013). Additionally, factors such as race and sex have been examined to determine their influence on the relationship between science self-efficacy and STEM career intent (Byars-Winston, 2006; Nauta & Epperson, 2003). Science self-efficacy, in addition to other sociocognitive factors, has been shown to have direct and indirect influences on science interest and STEM career intent (Lent, Sheu, Singley, Schmidt, & Gloster, 2008).

**Purpose**

The primary purpose of this study is to identify factors that predict science self-efficacy and STEM career intent for 9th graders, with special attention to how some of these factors’ relationship with science self-efficacy and STEM career intent vary by sex. This work extends the literature on the STEM pipeline by considering influences on science self-efficacy. The results from this work can be used to guide science education policy at the local, state, and national levels, and to direct science education programming in formal and informal settings.

**Research Questions**

The research questions that guide this study are:

1a. To what extent do a student’s person inputs (race, sex, science identity) predict student science self-efficacy?
1b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict student science self-efficacy?

1c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict student science self-efficacy?

2. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, percent White students in school, percent English language learners in school, percent of students on free and reduced lunch) predict student science self-efficacy?

3a. To what extent do a student’s person inputs (race, sex, science identity) predict a student’s STEM career intent?

3b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict a student’s STEM career intent?

3c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict a student’s STEM career intent?

4. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, percent White students in school, percent English language learners in school, % of students on free and reduced lunch) predict a student’s STEM career intent?
5. To what extent does the relationship between background contextual affordances and science self-efficacy vary by sex?

6. To what extent does the relationship between background contextual affordances and STEM career intent vary by sex?

**Conceptual Framework**

This study draws on Social Cognitive Career Theory (SCCT) proposed by Lent, Brown, and Hackett (1994). This framework suggests that the distal goals of career intent and career choice are mediated by self-efficacy and outcome expectations. The framework further suggests that several factors influence self-efficacy and therefore career intent. These factors include background characteristics such as race and sex, contextual factors such as SES and parental support, and informal learning experiences. Based on the SCCT model, there are pathways that directly and indirectly affect career intent, but all the pathways are mediated by self-efficacy. The factors that affect self-efficacy and the prime role that self-efficacy plays in influencing career intent make this framework ideal for studying the STEM trajectories and career intent.

**High School Longitudinal Study (HSLS:09)**

The High School Longitudinal Study of 2009 (HSLS: 09) was conducted by the National Center for Education Statistics in the fall term of the 2009-2010 school year (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). HSLS:09 is a nationally representative sample of over 21,000 9th graders from 940 schools that will be followed throughout their secondary and postsecondary years. The core research questions explore secondary to postsecondary transition plans, the paths into and out of science, technology, engineering,
and mathematics (STEM) fields of study and careers, and the educational and social experiences that are related to shifts in plans or paths. Data were collected from students, math and science teachers, parents, school counselors and administrators from September 2009 to April 2010. The HSLS:09 is an ideal data set to explore the factors that predict science self-efficacy and STEM career intent because it is a nationally representative sample and contains several variables related to science self-efficacy and STEM career intent. An examination of this data set sheds light on the pathways in and out of STEM fields and the development of science and math interests over time.

**Research Design**

This study will utilize hierarchical linear modeling (HLM) in order to determine the factors that predict student science self-efficacy and student STEM career intent by the age of 30. HLM is a multi-phased sampling technique that accounts for stratification, clustering and unequal probabilities of sampling (Rudenbush, 2002). It is ideal for survey data that are not obtained by simple random sampling, but instead are stratified by regions with schools as the primary sampling unit and students as the unit of interest, as is the case with HSLS:09. Failing to account for the clustering and stratification will likely results in biased estimates of the standard errors and increased likelihood of Type I error (Rudenbush, 2002).

**Significance of Study**

The significance of this study lies in the fact the majority of the studies to date on the factors that influence science self-efficacy and STEM career intent have not incorporated multiple demographic and contextual factors that influence science self-efficacy and STEM career intent, limiting our ability to understand the relative contributions of different factors.
that are involved in the formation of science self-efficacy and STEM career development. This study will directly address this limitation. Second, because this study comes from students who will be followed for several years, results from this study can inform future analyses of the students as they progress through school and enter the labor force. Additionally, this study examines a substantially large number of students who are representative of the U.S. population, which will allow us to generalize the findings to a wide range of students and afford us more power to detect the relationship between demographics, informal learning experiences, science self-efficacy, and STEM career intent. The better our understanding of science self-efficacy and STEM career intent, the greater our ability to address the issue of insufficient numbers of U.S. students majoring in STEM fields to keep with the demand and projected growth for these sectors.

Limitations

This study has limitations. First, this analysis was conducted only on the base year data for the 9th graders. Therefore, projections and extrapolations beyond the freshman year related to science self-efficacy and STEM career intent cannot be made. Second, only student level data are included in this study; teacher level and counselor level data are not included. While there may be teacher level factors that predict science self-efficacy and STEM career intent, this data cannot be ascertained from the HSLS:09 data because it gathers data at the beginning of the school year prior to the time when teacher and school-level factors could influence students.
Key Definitions

*Extracurricular Science/informal learning experiences.* Structured science activities that occur after the official school day has ended (Ucko, 2010).

*Informal Science.* Structured science activities that occur outside of the formal classroom (Dierking & Faulk, 1994).

*Outcome Expectations.* One’s belief about what will happen if he or she engages in specific activities (Lent, Brown, & Hackett, 1994).

*Science Identity.* One’s belief about whether or not they relate to science and scientists or see themselves in science (Carlone & Johnson, 2007).

*Science Self-Efficacy.* One’s belief about their ability to accomplish specific tasks related to science (Britner, & Pajares, 2006).

*Self-Efficacy.* One’s belief about their ability to accomplish specific tasks (Bandura, 1986).

*STEM.* The academic and professional disciplines of science, technology, engineering and mathematics” (The America Competes Act of 2010, P.L. 111-358, Section 2)

*STEM Career Intent.* The intent or goal action to major in a STEM field with the ultimate goal of performing in a STEM career (Britner, & Pajares, 2006).

**Chapter Summary and Overview of Study**

This chapter provided background and contextual information about the need to increase the pool of qualified native born STEM talent in the U.S. with a special focus on increasing underrepresented groups to the STEM pipeline and the role that science self-efficacy can play in accomplishing this goal. The lack of science self-efficacy plays a significant role in the STEM career choice of underrepresented groups (Navarro, Flores, &
Worthington, 2007) and is the focus of this study. Students with high science self-efficacy tend to perform better academically and are more likely to translate that confidence into long-term goals of becoming STEM majors and having STEM careers. The chapter included a description of the purpose of this study: to examine the factors that predict 9th graders science self-efficacy and STEM career intent. Advancing our knowledge of the factors can provide information to guide science education policy and practice. Chapter II discusses the theoretical framework that guides this study, SCCT, and reviews related literature. Chapter II is organized into the following sections: (a) introduction, (b) research questions, (c) theoretical framework, (d) person factors, (e) contextual factors, (f) conclusion, and (g) chapter summary. Chapter III presents a description of the methodology, research design, sample, variables, and data analysis techniques. Chapter IV provides the results of the study, and Chapter V provides a comprehensive discussion of key findings, limitations, implications, and directions for future work.
CHAPTER II: LITERATURE REVIEW

The purpose of this study is to determine the factors that influence science self-efficacy and STEM career intent. While several studies address factors such as race, sex, SES and support systems as they relate to interest in science (Jones, 2010; Luzzo & McWhirter, 2001; Roach, 2006), we have limited empirical evidence about the relative influence of these factors on the short-term goals of science interest development and the more distal goal of STEM career intent and the interaction between sex on with other factors on these outcomes. This study addresses this gap in the literature and thus informs science education policy and practice aimed at encouraging more U.S. participation in STEM. The literature suggests that the high school years are a pivotal time for the development of career intent (Van Langen, Rekers-Mombarg, & Dekkers, 2006) and have several points of entry into and out of the STEM pipeline as interests and goals change. By studying the influences on science self-efficacy and STEM career intent for entering high school freshmen, this study will help better predict long term the STEM career development process.

This literature review begins with addressing the importance of STEM education, followed by a description of the major constructs pertinent to this inquiry: science self-efficacy and STEM career intent. Next, the research questions and the theoretical framework (Lent, Brown & Hackett, 1994) that guides this study will be presented. After presenting the SCCT framework, a comprehensive review and synthesis of the literature that applies SCCT to examine factors that predict student interest in STEM, self-efficacy in STEM, and STEM career intent is presented. Benefits and drawbacks to the application of the SCCT model in the studies presented will also be discussed. The chapter concludes with a brief summary.
The strength of the STEM talent pool in the U.S. is critical not only to the country’s global economic competitiveness, but also to national security (National Academy of Sciences, 2007). STEM degrees are desirable to a wide range of employers because they incorporate 21st century skills such as critical thinking, problem solving and teamwork (Carnevale, Smith & Strohl, 2010). Developing these skills is critical because the problems that we face today such as global warming, protecting our food supply and the threat of nuclear war require a diverse and broadly functional skill set that is embodied in STEM degrees (Muriname, 2011). With the recent reforms in STEM education that emphasize an integrative strategy of teaching instead of the traditional silo approach, skills such as teamwork, effective communication and innovation can be fostered, thus allowing the U.S. to keep pace with fast-paced technological advancements.

Not only do STEM degrees provide a comprehensive skill set, but they also advance social justice and equity. For example, attainment of STEM degrees provides a chance at economic parity for students born into low-income and low SES families since individuals who have STEM degrees are reported to accrue one million dollars more over a lifetime compared to people with non-STEM degrees (Carnevale, Smith & Strohl, 2010; National Academies, 2010). The research shows that even when students enter the STEM pipeline, many of them do not stay due to reasons such as low confidence in math and science, past poor performance in STEM subjects, discouragement, and lack of role models and mentors (Jones, 2010; Roach, 2006; Quimby & DeSantis, 2006). This “leaky” pipeline referred to in the literature (Blickenstaff, 2005) is more pronounced and evident for females and ethnic minorities who are underrepresented in STEM (National Academies, 2010; Russell &
Atwater, 2005). Because of this trend in attrition, it is important not only to address the issue of attracting students to the STEM pipeline, but also to determine ways to improve persistence. In order to better direct science education policy and practice, the factors that influence entry into and sustainment throughout the STEM pipeline must be investigated and understood comprehensively.

**Self-Efficacy**

Self-efficacy is defined as one’s belief about their ability as it relates to a specific subject or act (Bandura, 1997; Pajares, 2005; Zimmerman, 2000). The term also refers to guided actions or goals that result from this belief. For example, someone with high self-efficacy in a particular subject will engage in specific activities or set goals related to that subject. In contrast, individuals with low self-efficacy regarding a particular subject or act will tend to avoid interaction with or engaging in activities related to that subject.

Self-efficacy holds tremendous potential in understanding and explaining performance, interest and career intent in specific academic disciplines (Betz, 2004; Lent, Brown, & Larkin, 1986; Zimmerman, Bandura, & Martinez-Pons, 1992). While there have been differences found related to race, sex and income status, it is widely accepted that self-efficacy influences interests, goals and career choice (Eccles, 1994; Lent, Brown, & Hackett, 1994). Self-efficacy also influences performance in specific tasks. For example, students who believe that they will make an “A” in a course tend to make grades consistent with their beliefs and will attribute their failures to not giving enough effort rather than to not being smart enough (Zimmerman, 2000). In contrast, students who have low self-efficacy as it relates to grades in a particular subject tend to make lower grades consistent with that belief,
even if they are smart enough to do better. The profound effect of affective domains, such as self-efficacy in academic performance on interest and career goal development, has been the focus of research into strategies that enhance science education, especially for underrepresented and low SES groups who tend to also underachieve compared to their White counterparts (Forsyth, Lawrence, Burnette, & Baumeiste, 2007).

**Science Self-Efficacy**

Science self-efficacy refers to one’s belief in their ability to accomplish science-related tasks (Britner & Pajares, 2006). The study of science self-efficacy is one strategy to address the low representation of women and minorities in STEM and has been a promising area of research for the last decade (Dietz, Anderson, & Katzenmeyer, 2002). Previous research has shown that science self-efficacy is associated with achievement in science across grade levels (Betz, 2004; Betz & Hackett, 1983; Lent, Brown, & Larkin, 1986; Taylor & Betz, 1983). At the college level, science self-efficacy has been shown to correlate with science career intent. Gwilliam and Betz (2001) examined the reliability and validity of three measures of science and math self-efficacy of Black and White college students. The measures were found to be reliable in both racial groups and predicted considerations of majors and careers in the sciences. Specifically, they found that with Black women, science self-efficacy was found to have an effect on science career choice. Sex differences in both math and science self-efficacy were found with males having higher efficacy in both cases. One limitation of this study, however, is that the sample consisted of students who had already selected science and math-related majors and did not include students who opted out of these majors or who were discouraged from this choice.
While sex appears to play a role in science self-efficacy, the results also may be more nuanced for women. For example, while women are gaining strides in the biological sciences, they remain severely underrepresented in the physical and computer sciences (National Science Foundation, 2013) and continue to report lower science self-efficacy compared to their male counterparts (Quimby & DeSantis, 2006). Furthermore, Heilbronner (2012) found that college-educated women recalled having lower self-efficacy than men when asked to reflect back on their college education and their decision to enter biological fields as opposed to computer or engineering areas because of a lack in confidence.

With respect to ethnic minorities, low confidence or science self-efficacy is one reason for choosing non-STEM majors and careers. Lewis (2003) highlights this lack of confidence in science as one of six factors contributing to the underrepresentation of minorities in STEM fields and suggests the need for further research into the role of science self-efficacy. Designing science learning environments that enhance confidence or self-efficacy in science will go a long way to encourage long term interest in STEM careers and lower attrition rates based on race and sex (Lewis, 2003). While self-efficacy or confidence in science is considered a short-term construct that is often measured employing a pretest/posttest research design, STEM career intent is a more distal or longitudinal construct that develops over time (Lent, Brown, Brenner, Chopra, & Davis, 2001).

**STEM Career Intent**

Lent, Brown and Hackett (1994) suggest that the process an adolescent undergoes to choose a career occurs over a period of time and that it is influenced by self-efficacy and outcome expectations. Additionally, other factors such as race, sex, SES and informal
learning experiences also play a role. Researchers of STEM career intent suggest that interest in science, especially when developed at an early age, has a significant influence on choosing a STEM career (Cole, Ray, and Zanetis, 2011). Additionally, since having accurate information about specific career paths can demystify the career choice process, having exposure to science and knowledge of STEM careers (Beggs, Banthum, & Taylor, 2008) positively affects STEM career interest. Science self-efficacy has also been shown to predict STEM career intent (Britner & Pajares, 2006; Chen & Zimmerman, 2007; Kay & Knaack, 2008; Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006).

Research further suggests that the long-term development of STEM career intent can be positively influenced by repeat participation in STEM outreach programs, through interaction with role models and mentors, and in positive and engaging science learning environments (Richardson & Houston, 2006). The goal of STEM outreach programs and/or interventions is to expose students to STEM careers by providing exciting and engaging experiences that they would not normally encounter in their school environments. The intended outcomes of these programs are that participants will choose to pursue these careers and feel equipped to succeed. Several studies suggest that positive influences on STEM career intent are experiences with informal and non-formal science settings, mentors, and knowing someone in a STEM field (Farmer, 1999; Packard & Nguyen, 2003). Interest in science during a student’s middle school and high school has also been proven to predict STEM career intent (VanLeuvan, 2004; Villarejo, Barlow, & Kogan, 2008).

While there is much research on persistence in STEM majors at the college level, less focus has been placed on STEM career intent and actual choice, which are precursors to
entering STEM majors. Chen and Weko (2009) found that the percentage of students entering STEM fields was higher among male students, students financially dependent on family, foreign students, and students who came from an advantaged family background. Finally, Wang (2013) employed SCCT to understand the entrance into STEM majors of a sample of recent high school graduates. The results indicated that the largest impact on STEM major entrance was STEM career intent, and that this intent was directly affected by 12th grade math achievement, exposure to math and science courses, and math self-efficacy beliefs.

Since many of the studies on the factors that influence science interest and STEM career intent only study variables in isolation, there is a need to examine several factors simultaneously in order to provide a more comprehensive picture of the STEM career intent development process and to provide more predictive power. Additionally, many of these studies occur at the college level, after a student has already chosen a STEM career, and therefore seek to examine persistence or attrition. There are far fewer studies that examine STEM career intent at the secondary level, and few studies go beyond the analysis of demographic and achievement factors such as GPA and standardized test performance. Thus, by examining several factors simultaneously in order to determine which factors predict science self-efficacy and STEM career intent and to what extent they predict them, this study fills this gap in the literature.
Research Questions

The research questions that guide this study are:

1a. To what extent do a student’s person inputs (race, sex, science identity) predict student science self-efficacy?

1b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict student science self-efficacy?

1c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict student science self-efficacy?

2. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, percent White students in school, percent English language learners in school, percent of students on free and reduced lunch) predict student science self-efficacy?

3a. To what extent do a student’s person inputs (race, sex, science identity) predict a student’s STEM career intent?

3b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict a student’s STEM career intent?

3c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict a student’s STEM career intent?
4. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, percent White students in school, percent English language learners in school, percent of students on free and reduced lunch) predict a student’s STEM career intent?

5. To what extent does the relationship between background contextual affordances and science self-efficacy vary by sex?

6. To what extent does the relationship between background contextual affordances and STEM career intent vary by sex?

**Theoretical Framework**

In order to determine how we can attract and retain adolescents, especially underrepresented groups to STEM careers, we must understand the processes by which one chooses a career. Self-efficacy plays a significant role in influencing adolescents’ STEM career intent. Social Cognitive Career Theory (SCCT), proposed by Lent, Brown, and Hackett (1994), is a useful theoretical lens to understand the mitigating factors that lead to STEM career intent and the unique situation that underrepresented groups are in with respect to their career choice. SCCT is based on three interrelated models of career interest development, choice-making, and performance. This framework is derived from Bandura’s (1986) Social Cognitive Theory (SCT) that suggests personal agency guides human motivation and behavior through the constructs of self-efficacy, outcome expectations, and goals. Bandura defines self-efficacy as one’s beliefs about their ability to complete a task that will cause a specific outcome. The authors extend Bandura’s general theory to choosing careers by offering three variables that influence the career development process: 1) interest
development, 2) career choice, and 3) performance. The extent to which these variables relate to personal (race, sex, etc.) and contextual (environment, supports, barriers, etc.) factors are the main focus of the framework. In essence, a person’s belief about their ability affects interest and ultimately career choice. Therefore, students with high levels of self-efficacy can visualize positive outcomes regarding specific career related tasks and will most likely choose to pursue that career (Bandura 1999). The model suggests 12 pathways of interaction:

Path 1 – self-efficacy predicts interest
Path 2 – outcome expectations predict interest
Path 3 – Interest predicts choice goals
Path 4 – choice goals predicts choice actions
Path 5 – choice actions predict performance
Path 6 – performance predicts learning experiences
Path 7 – self-efficacy predicts outcome expectations
Path 8 – outcome expectations predict choice goals
Path 9 – choice goals predict choice actions
Path 10 – self-efficacy predicts choice goals
Path 11 – self-efficacy predicts choice actions
Path 12 – self-efficacy predicts performance

The constructs presented in the career choice model are organized into personal inputs, background contextual affordances, contextual influences proximal to career choice, and other contextual factors. Personal inputs refer to those factors that are socially
constructed such as race, sex, and health status. Background contextual affordances refer to things like family history, parental support, culture and heritage. Informal learning experiences include those that are outside of the classroom that may occur in the home or community. Self-efficacy and outcome expectations are sociocognitive factors that refer to motivation and behavior.

The rationale for the development of SCCT (Lent, Brown & Hackett, 1994) was to address a previous lack of theory integration. Three goals of the framework are to: 1) integrate conceptually related constructs such as self-efficacy and self-concept; 2) to more fully explain common outcomes such as satisfaction and stability; and 3) to relate seemingly diverse constructs such as self-efficacy, interests, abilities, and needs. The core of the framework lies in how three sociocognitive mechanisms (self-efficacy, expected outcomes, goals) relate with person (i.e., sex, race), contextual (i.e., support systems, socioeconomic status - SES), and experiential or learning factors.

According to Social Cognitive Theory (Bandura, 1986), self-efficacy is largely determined and modified by four sources: 1) personal performance accomplishments, 2) vicarious learning, 3) social persuasion, and 4) physiological states and reactions. Personal performance accomplishments suggest that success experiences with a given task tend to raise efficacy estimates, while repeated failures lower them. Vicarious learning refers to watching others succeed or fail, which in the case of observing role models, can have positive effects on efficacy. Social persuasion refers to the effect of others and or events on one’s decisions and actions. Some examples of social persuasion are peer pressure or watching engaging shows on TV. Finally, physiological states refer to fatigue, anxiety or
stress that can affect performance of a given task, and thus efficacy. An example of this would be anxiety prior to a science or math test that one cannot overcome.

This study has two main regression models based on SCCT. Model 1 (Figure 1) employs multiple regression to predict science self-efficacy, and Model 2 (Figure 2) employs logistic regression to predict STEM career intent. Variables that are “grayed out” are not included in the study models because there were no indicators available in the dataset.
Figure 1. *Diagram of Model 1 Variables*

**School Level Predictor Variables**

- School type (public, catholic, other private)
- School locale (city, suburban, town, rural)
  - % White students
  - % English language learners
  - % Free/reduced lunch students

**Student Level Predictor Variables**

- Race (Black, Native Alaskan/American Indian, Hawaiian/Pacific Islander, Hispanic, Asian)
- Sex
- SES
- Extracurricular Science Activities
- Participation in Outreach Programs
- Science Identity
- Parental Support
- Parental Science Homework Self-efficacy

**Outcome Variable**

Science Self-Efficacy
Figure 2. Model 2 Logistic Regression Variables
According to SCCT Lent, Brown & Hackett, 1994), people must interact, engage, and be exposed to activities in order to develop an interest in them. As it relates to career choice, this model suggests that young people choose a career over a period of time where they engage in specific career related activities, are able to see themselves in that career, and then begin to make plans to pursue it. While the vast majority of the applications of SCCT have been in the vocational and psychological domains, the framework has evolved over the years to include applications to STEM and racial/ethnic minorities’ pursuit of math and science related careers. The bulk of these studies are tests of multivariate models of SCCT involving path analysis that include relatively small, limited generalizability survey measures of self-efficacy, interests, outcome expectations, goals, choice, supports and barriers. This literature review focuses on SCCT applications to STEM via examination of the impact of these sociocognitive variables on the career development process.

**Person Factors**

**Sex**

SCCT suggests that person factors such as sex play a key role in career choice. While sex is a biological factor, sex is a sociocultural concept that has profound influence on career choice, especially for girls and women in nontraditional careers such as STEM. A study by Nauta and Epperson (2003) tested a version of the SCCT model on 204 high school girls who voluntarily attended science or math-related conferences. The goal of the 4-year longitudinal study was to predict the choice of a STEM college major and STEM self-efficacy and outcome expectations in college. The girls were surveyed prior to and after entering college. The results showed a direct link between ability and self-efficacy. In addition, the results
indicated that college STEM outcome expectations were associated with plans to become a leader in a STEM field. Contrary to the SCCT model predictions, a relation was not found between informal learning experiences and self-efficacy. This could be due to a lack of range in experiences since all the girls were already on a college preparatory track and taking similar science and math courses. Another limitation is that the authors did not assess outcome expectations in high school, which might have provided long-term data to validate the SCCT model. One implication of the study is that pre-college science experiences may play a role in not just attracting girls, but also sustaining them in STEM majors over time.

In addition to self-efficacy, Quimby and DeSantis (2006) examined the role model influence as a predictor of career choice for 368 female undergraduates across Holland’s (1997) six RIASEC (Realistic, Investigative, Artistic, Social, Enterprising, and Conventional) career types. The results showed that the levels of self-efficacy, role model influence, and career choice consideration differed across types but showed the greatest overall mean scores for the social career type. More significantly, the role model influence showed more contribution to career choice than self-efficacy. The study demonstrates that mentoring programs and role models may play an important role in attracting girls to nontraditional careers, perhaps due to the personal interaction, opportunity for authentic advice, and chance to debunk negative stereotypes.

**Race, Ethnic Identity, and Culture**

The role of race, culture and ethnic identity also have profound influence on career choice by dictating access to quality STEM education, STEM career information and science-related experiences. Byars-Winston (2006) employed SCCT to examine the
relationship between Racial Ideology (Sellers, Rowley, Chavus, Shelton, & Smith, 1997) and self-efficacy, outcome expectations, career interests and perceived career barriers on 141 Black undergraduates at a Historically Black College/University (HBCU). The rationale for the study was that most of the SCCT research at the time had focused on the cognitive variables of career behavior while excluding cultural and other types of person variables. The theory proposes four racial ideologies (nationalist, assimilationist, humanist, and oppressed minority) that represent how Black people should act. The results showed support for two (nationalist and assimilationist) of the four racial ideologies in predicting the assessed sociocognitive variables. The study also showed support for the SCCT model in that interests predicted career considerations. The overall implication of the work is that it offers support for including race-specific factors in career choice examinations. However, it should be noted that since members of racial groups may internalize racialized experiences differently, this work suggests that race alone may not explain the nuisances and complexity in the career decision process.

Similarly, a study (Gainor & Lent, 1998) of 164 first year Black undergraduates at a predominantly white university incorporated Racial Identity Theory (Cross, 1991; Helms, 1990) to the SCCT model assessing self-efficacy, outcome expectations, interests and choice intentions. Racial Identity Theory holds that Blacks undergo a maturation process that involves the development of various racial identity statuses (pre-encounter, encounter, immersion/emersion, and internalization). These attitudes represent a certain level of racial consciousness and subsequent responses to race-related experiences. Overall, the results were very similar to studies of White American students (Lent, Lopez, & Bieschke, 1991, 1993)
and showed a good fit of SCCT for math interests and choice intentions. Self-efficacy and outcome expectations jointly predicted interests, and interests predicted choice intentions across racial identity attitude levels. While racial identity attitudes only had a small relationship to the sociocognitive variables overall, internalization attitudes (reflecting a sense of pride and security in one’s race) were positively related to perceived social persuasion regarding math and science options. While the study supports the application of SCCT across racial/ethnic groups and across racial identities, it also supports incorporating race and culture-sensitive person factors within SCCT to study Black populations.

Quimby and Wolfson (2007) examined the sociocognitive predictors (investigative self-efficacy, outcome expectations, perceived barriers, support, and environmental concerns) on the development of Black high school students’ career interests in environmental science at an urban magnet polytechnic school. The results showed that the predictor variables overall accounted for a significant amount of the variance in interest, but in the final model, only investigative self-efficacy proved to be significant, showing limited support for the SCCT model. These students perceived few ethnic and sex-related career barriers, findings that are in contrast to the study by Luzzo and McWhirter (2001) which showed that ethnic minority students perceive many educational and career-related barriers. Additionally, no relation was found between barriers and interest in environmental science, as was found in a study by Constantine (2005) that showed sex and ethnic-related career barriers were positively related to career interest and indecision. The results in the Quimby and Wolfson study may be due to the fact that many students were gifted. This suggests the need for further research to determine the role of “giftedness” in SCCT research on Blacks’ STEM
career intent. A final implication of the study is that the fact that many minorities are disproportionately adversely affected by living close to hazardous areas and often victims of environmental problems can be leveraged to improve interest in environmental science from a social justice vantage point for these groups.

Gloria and Hird's (1999) evaluation of 687 undergraduates showed ethnic variables (ethnic identity, other-group orientation) were more significant predictors of career self-efficacy and trait anxiety (e.g. worry) for racial and ethnic minorities than for White students. White students had higher career decision-making and self-efficacy and lower trait anxiety, ethnic identity, and other-group identification. Other-group identification was the greatest predictor of career self-efficacy for the minorities in the sample, which suggests that affiliation with the dominant (White race in this case) group would most likely lead to vocational development. This study suggests that the experience of being “different” may cause anxiety on levels that are often unseen, unmeasured and need to be evaluated further.

A study of Mexican American middle school students’ goal intentions in math and science by Navarro, Flores, and Worthington (2007) provided partial support for the SCCT model because it showed past performance in math and science and perceived parental support influenced self-efficacy. Self-efficacy predicted expected outcomes, which also correlated with interest and career goals. Contrary to predictions based on the model, generation status, Anglo orientation, and Mexican orientation did not predict math/science past performance accomplishments, nor did past performance accomplishments predict math/science outcome expectations. Furthermore, Anglo orientation and perceived social support from parents, teachers, classmates, and a close friend did not predict math/science
goals. These contradicting results suggest background factors may interrelate to sociocognitive factors differently for this sub-sample of the Mexican American student population compared to others.

Mau and Bikos (2000) also proved race and sex to be predictors of educational and vocational aspirations. They followed a nationally representative sample of 10th grade students for two years beyond high school. The results showed females had higher educational and vocational aspirations than males, and Asian Americas had the greatest increase in educational aspirations over time. The overall implication of the work is that career counseling programs should include examinations of the influence of race and sex and it provides further support for outreach programs such as Upward Bound that are targeted at disadvantaged students whose populations often overlap with underrepresented groups in STEM. The intersection of race and sex may be a fruitful area to investigate with respect to SCCT according to a study by Hackett and Byars (1996). They reviewed the literature related to research on Black women’s career decisions and found a significant gap in this area. The authors proposed that culturally-linked social “ism” experiences such as racism and sexism may affect the nature of self-efficacy sources to which Black women in particular are exposed.

**Career Choice (STEM Career Intent)**

Researchers on science self-efficacy posit that students’ belief in their ability to succeed in science tasks, courses, or activities influence their perceptions and attitudes about science and desire for further study in science and more distal science career goals (Pajares, 1996, 2002, 2003). Students who have a strong science self-efficacy are more likely to
maintain positive attitudes about science, have high science achievement, and choose additional science experiences and activities (Britner & Pajares, 2006). This makes science self-efficacy a key focus for science educators and policy makers who want to positively affect STEM career intent. Bandura (1986) contended that students’ self-efficacy beliefs are often better predictors of academic successes than assessments of abilities via such mechanisms as standardized tests. The literature suggests that there are several factors in addition to science self-efficacy that positively affect STEM career intent (Jones & Howe, 2000). Those factors include early exposure to STEM, positive science learning experiences, having career information, role models/mentors, and seeing others that look like them succeed in STEM (Nauta & Epperson, 2003).

The literature suggests that opportunities for students to engage in scientific research improve interest in STEM and STEM career intent (National Academies, 2010). Summer enrichment programs and undergraduate research experiences offer a chance to do this (Vanleuvan, 2004). For example, a summer bridge program at the University of Akron designed to encourage students to consider choosing STEM careers found that 86% of the participants went on to choose STEM careers because of that program (Jiang, 2010). Similarly, a summer bridge program at Bowling Green State University found that early acclimation to a university through a summer program influenced students to attend and choose STEM majors (Gilmer, 2007).

VanLeuvan (2004) investigated the career aspirations of girls from 7th to 12 grade and found that perceived demands of STEM professions such as workload and math engagement were barriers. The study also found that many of the girls did not see a clear STEM career
pathway that combined work and their plans for marriage and family. Finally, the learning and discovery aspect of STEM careers were most engaging among those who rated positive views of STEM careers. This study suggests that active engagement with science that includes inquiry should lead to positive views of science. The study also suggests that barriers to achievement in STEM fields for Black women begin in elementary and secondary school. Also, a survey conducted by the Society of Women Engineers found that only 10% of the young women in their study considered engineering as a career because American culture, through multimedia, had led them to believe that they could not excel in STEM careers and caused them to have negative views (Roach, 2006). A similar study of minorities and women showed that a large number of survey respondents had an interest in science by age 11, yet they did not pursue STEM careers because they were discouraged by college professors. A major influencing factor was the stereotype that science is not for girls or minorities. The study also showed that a lack of quality science education in poor school districts and the projected cost of education for STEM majors had an influence on participants STEM career intent (U.S. Women and Minority, 2010).

A survey of students who did pursue STEM careers found the following factors influenced their choice: 1) the belief that they could do science, 2) their ideas about knowledge, and 3) stereotypes about STEM careers (Jones, 2000). Boys and non-minorities had a more positive self-assessment (belief that they could do science) and were most likely to pursue a STEM career. Conversely, girls and minorities were discouraged by society and stereotypes in the media. They believed that knowledge was fixed and could not be improved, and would most likely not pursue STEM careers (Jones, 2010). Student-teacher
interactions were also found to be important. Survey results showed that girls believed they received less attention from teachers than boys, and this influenced them negatively. It was also shown that boys are more interested in science topics and are most likely to pursue STEM careers because of the extra attention they receive (Jones & Howe, 2000). A similar study found that girls who had an interest in science were more likely to pursue careers in the biological sciences over the physical sciences because they wanted to help people (Jones, 2000). Additionally, the girls expressed that their choice was influenced by their relationships with family and peers. This study also found differences in the number and type of out of class science experiences for boys and girls and this affected their attitude about science (Jones, 2000). Moreover, studies have shown that STEM majors having a family member in a STEM career influenced them in a positive way (Quimby & DeSantis, 2006). However, the quality of science teaching and the perception that the professor’s research was more important than teaching caused students to leave STEM majors. It was also reported that background characteristics such as sex, financial situation, parents’ education and social interactions, also had effects on in interest in science and science career intent (Whalen, 2010). Finally, an investigation by Lewis (2001) showed that the number of math and science courses, knowledge of viable careers in science and a lack of mentoring affect underrepresented minorities choice of STEM careers and attitudes about science.

**Background or Contextual Factors**

The SCCT model suggests that contextual factors such as environment, supports and barriers can affect the career choice process through various paths of influence that are mediated by learning experiences. According to Lent, Brown and Hackett (1994), early and
ongoing learning experiences affect self-efficacy, which in turn affect interests, goals and career choice. Lent, Brown, Brenner, Chopra, and Davis (2001) applied SCCT to STEM careers to examine the extent to which contextual barriers and supports influenced career choices. The authors examined self-efficacy, coping efficacy, outcome expectations, interests, goals and perceived contextual barriers and supports. They found that self-efficacy and outcome expectations were predictive of choice, and barriers and supports were indirectly linked to choice through self-efficacy. Some of the barriers identified were negative comments and discouragement from family members, not having enough money for computers and tutoring, poor quality teachers, and discrimination based on sex and race. Supports included encouragement from family, role models and mentors, community members to help with math and science problems and money to pursue STEM degree.

Flores, Navarro, Smith, and Ploszaj (2006) examined the nontraditional career choice of 302 Mexican American adolescent men using SCCT. They hypothesized that background contextual variables (acculturation level, parental support, perceived occupational sex barriers) would predict nontraditional career self-efficacy. The results supported a modified path model that showed a direct link between the father’s nontraditional career choice and goals. The results showed self-efficacy to be predicted by acculturation level and parental support. Contrary to SCCT predictions, barriers did not predict self-efficacy and self-efficacy was not directly predictable of choice. Implications of the Flores et al. study are that differences in the effects of family support and family educational/career background factors between minority populations may be mediated by the hierarchy in roles and status the culture places on sex. For example, the Mexican American culture is very patriarchal and
masculine-oriented, while the Black culture is very matriarchal as many Black children reside in single parent homes headed by the mother. Additionally, the varied acculturation experiences of those whose ancestors came to the United States via immigration versus slavery may also play a role.

Constantine and Flores (2006) tested the relationship between the contextual factors of psychological distress, perceived family conflict and vicarious career-related constructs on 329 Blacks, Asian Americans and Latino college students. They found across all levels that high levels of psychological distress predicted more career indecision, which in turn was associated with lower career certainty and greater perceived family conflict. Lower levels of perceived family conflict predicted higher career aspiration for all three groups. The overall implication of the study is that holistic approaches that consider familial, personal and career variables on career choice should be employed.

Ojeda and Flores (2008) tested the SCCT model evaluating contextual factors (sex, generation level, parents’ education level, and perceived barriers) related to educational aspirations of 186 Mexican American high school students. The results showed that the factors predicted aspirations in the overall model, but within the model barriers was the only predictor. Also, the unique influence of sex was not supported in this sample. Implications of this study are that career counselors and educators should examine Mexican American students’ beliefs about the resources they need and effective strategies to identify and overcome barriers.

Contextual factors, specifically supports and barriers, were examined by Fouad et al. (2010) to determine differences based on sex and development level (middle school, high
school, and college) for pursuing science/math coursework and/or careers. Over 1500 students in algebra, Pre-calculus and calculus classes were evaluated. The results indicated both sex and developmental differences in perceptions of barriers and supports. For example, teachers were the biggest support and barrier for females at all three levels. Lack of role models was a top barrier for males at the middle school level, teachers’ lack of inspiration was the top barrier for male high school students, and lack of opportunities outside of school was the top barrier for college males. One implication of the study is that students at the middle school level may not be aware of the effect of sex socialization and peers on their career choice. A limitation of the work is that educational level was used as a proxy for development level instead of measuring actual developmental stages. The study also reinforces the influence of teachers and role models on girls in particular, and the importance of targeting interventions and career counseling at the middle school level for the greatest impact.

**Family and Parental Support**

Parental support can be seen as a form of social capital in that it serves as a resource to students to help them increase their advantage (Pernal & Titus, 2005). Support mechanisms, in particular parental support, can be not only a positive influence on adolescent interest in school, but also can affect students’ long term goals of attending college. With underrepresented groups in particular, finding effective ways to encourage greater parental support is a beneficial strategy to help narrow the achievement gap compared to White students. A study by Archer-Banks and Behar-Horenstein (2008) examined the perceptions of Black parental involvement in their children’s middle school experiences and how their
beliefs about this involvement impacted the educational experiences of their children. Two focus group interviews were conducted with Black parents. While the participants viewed parent involvement as important, they reported that family structure and socioeconomic status, school personnel's expectations of parents, and the practices and policies of middle school personnel influenced their level of involvement. The participants suggested that setting higher expectations for Black students, establishing flexible meeting locations, offering workshops for homework help at home, and creating cultures that believe parents care would likely increase Black parent involvement.

Similarly, a study by Jeynes (2005) using the 1992 National Educational Longitudinal Study (NELS) data set examined the effects of parental involvement on the academic achievement of Black 12th grade youth. The results indicated that parental involvement had a positive influence on the students’ educational outcomes. The study also confirmed the strong link between parental involvement and SES, suggesting that parents of higher income status were found to be more involved in their child’s education. Once SES was controlled for, there was no significance found regarding parental involvement for students of low and high SES. The analysis also indicated that parents were slightly more likely to be involved in the education of their daughters than they were in the education of their sons.

A study by Ma (2009) focused on family socioeconomic status (SES) and parental involvement to examine potential family influences on college major choice by sex, race/ethnicity, and nativity. Using data from the National Education Longitudinal Study 1988-1994 (NELS: 88-94), Ma’s study found that lower SES children were found to favor more lucrative college majors. Family SES was found to have different influences on men
and women as well as for racial minorities and Whites. Additionally, due to socialization based on sex, women tend to be attracted to more altruistic and helping careers that are not as lucrative as business or high tech careers. However, according to this study, when SES is factored in, women of low SES tend to choose more lucrative careers commensurate with their male counterparts. This suggests that a chance at economic equity and parity does influence students of lower SES more so than sex, regardless of parental support levels.

Parental involvement in assisting their children with homework has been of special interest over the last few years. In a synthesis of research on the effects of parent involvement in homework (Patall, Cooper & Robinson, 2008), a meta-analysis of 14 studies revealed that training parents to be involved in their child’s homework results in (a) higher rates of homework completion, (b) fewer homework problems, and (c) possibly, improved academic performance among elementary school children. A meta-analysis of 22 samples from 20 studies correlating parent involvement with achievement-related outcomes revealed varying outcomes based on class subject as well as different types of parental involvement needed as students progress through higher grade levels. Finally, the study suggested that the relationship between involvement in homework and achievement differed based on grade level. A positive relationship was found between support and performance at the elementary and high school levels, but a negative relationship was found at the middle school level. This may be due to the fact that middle school is often a transition period for adolescents and other factors such as puberty and social/peer interactions may have an influence on learning.

The role of parental support in encouraging interest in science and math and academic success among underrepresented groups in particular is of increasing interest to STEM
educators. Yan and Lin (2010) studied the relationships of three dimensions of parent involvement (family obligations, family norms, and parent information networks) to 12th-grade students' mathematics achievement and ways in which these relationships varied across four racial and ethnic groups (i.e., Caucasians, Blacks, Hispanics, and Asians). Using data from the National Education Longitudinal Study: 1988 (NELS: 88), the authors found that parental involvement was viewed as a form of social capital for White students and explained the math achievement of those students. For Hispanic families, close ties between parents and their children showed a positive effect on math achievement. Finally, expected educational outcomes were the strongest positive influence on math achievement in the senior year. The study suggests that parental involvement as a form of social capital is grossly understudied and that educators should explore social networks outside of the family as well to understand the role that it may play in influencing student achievement.

Further support for the positive relationship between parental involvement and student achievement was provided by Fan and Chin (2001). The authors’ meta-analysis showed that parents who had high expectations for their children and their future had a strong positive relationship to achievement. Furthermore, this relationship was stronger when academic achievement was represented by metrics such as GPA as opposed to specific subject content. This study suggests that setting high expectations—even though students may not believe that they are attainable—may have far-reaching and long-lasting positive influences on student academic achievement.

Learning Experiences
Science learning experiences that are constructivist in nature, hands-on, and inquiry-based are not only engaging for students, but effective. In his book *Teaching and Learning about Science: Language, Theories, Methods, History, Traditions and Values*, Hodson (2009) delineates the difference between “learning science” and “doing science.” He discusses the value of incorporating scientific investigation in the learning about science and proceeds to break down its four major stages which include: 1) design, 2) performance, 3) reflection and 4) reporting. He goes on to state that:

- students should be given the opportunity to frame their own questions and problems,
- devise their own investigative strategies and data collection methods, interpret and make sense of their findings, share their experiences with others, and generally move in the direction of connoisseurship. (p. 202)

In addition to the experiential learning approach, project-based learning has also proven to be effective in engaging students in science and improving overall interest and attitudes. A study by Kanter and Konstantopoulos (2010) showed that by giving teachers and students a chance to conduct scientific research through project-based learning during a summer program, the teachers gained confidence in their science teaching and use of technology and lab equipment, and student achievement also increased.

A study conducted by the Burroughs Wellcome fund found that most of what children learn about science is learned outside of the formal school classroom (cited in Thompson & Bond, 2006). Informal settings continue to be of interest to science educators because of their promise in engaging underrepresented groups who have historically been discouraged from STEM disciplines. Simpson and Parsons (2008) showed that informal science
education settings provide an opportunity for underrepresented minorities to explore hands on science in a nonthreatening and non-evaluative environment. The authors contend that these settings may be a “more open venue than formal school settings for incorporating the cultural values of students” (Simpson & Parsons, 2008, p. 294). Informal science learning environments refer to contexts that are outside of the traditional classroom (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003). Some examples of informal learning settings are museums, parks, zoos, nature preserves and planetariums. The “hands on” aspect of informal science settings are particularly engaging for students. Informal science learning settings offer many benefits that the traditional classroom does not offer, such as the chance for more team work, working with resources that most classrooms do not have, and the chance to interact with scientists. McComas (2006) cautions educators that finding the right balance between meeting the expectations of the formal classroom and leveraging the benefits of informal science settings can be a challenge.

**Conclusion**

Based on the studies presented the following have been found to positively influence science self-efficacy and STEM career intent:

- Early exposure to STEM
- Hands-on, inquiry-based science activities
- Role models/mentors in STEM
- Positive science learning experiences in and out of school
- Encouragement from peers, family, teachers and community
- High achievement/performance in science and math
- Opportunities to explore STEM careers and obtain career advice
- Support mechanisms at all junctures of the STEM pipeline
- Science activities that relate to everyday life and students’ point of entry
- Teachers’ beliefs about student learning capacity and teacher science self-efficacy
- Parental support

While the majority of the studies reviewed show overall support for the SCCT models, contradicting results indicate the need for refinement and adaptation of the framework to include other person and contextual variables and other theories such as racial and feminist theories, social class, language-related barriers, and identity constructs that may have more predictive power in explaining observed trends and relationships. Moreover, since SCCT is a relatively new framework, there need to be more longitudinal studies, especially on underrepresented populations in STEM, to test the proposed pathways and models for robustness and appropriateness. Finally, since the introduction of SCCT in 1994, several instruments have been developed based on its sociocognitive variables that need to be further refined and tailored for specific domains within STEM disciplines that may address unmeasured differences that an interdisciplinary view of STEM fields may not capture. This study addresses a few gaps in the literature by examining on a large scale, the science self-efficacy and STEM career intent of first year high school students, and doing so while examining multiple variables simultaneously. This will allow us to determine the relative contributions of each factor.
Chapter Summary

This chapter provided a discussion of the state of STEM education in the U.S. and the concern over meeting the demands for a skilled technical workforce. The importance of STEM to the nation’s economy and global competitiveness was also discussed. Next, a discussion of the two primary constructs of interest for this study—science self-efficacy and STEM career intent—was presented. This chapter then outlined the study’s theoretical framework (SCCT) and described research on factors in SCCT that influence self-efficacy in STEM and STEM career intent. Person inputs based on SCCT such as sex and race were discussed as they relate to developing interests in science, confidence in science, and goals to pursue STEM careers. Contextual factors that may affect science self-efficacy such as supports and barriers, socioeconomic status, parental influence and science identity were identified. Lastly, the role of positive science learning experiences inside and outside of the classroom was also discussed. Chapter III describes the research methodology used to test the hypotheses presented in this review. It is organized into the following sections: (a) introduction, (b) research questions, (c) data collection, (d) sample, (e) instrumentation, (f) description of the variables, and (g) analysis. This chapter describes the specific statistical procedures that will be used to address the research questions.
CHAPTER III: METHODOLOGY

The purpose of this study is to identify the factors that predict 9th grade students’ science self-efficacy and STEM career intent. This chapter explicates the research design, which includes descriptions of the sample, data collection, variable selection, and statistical analyses. Drawing on SCCT (Lent, Brown, & Hackett, 1994), the research questions that guide this study are:

1a. To what extent do a student’s person inputs (race, sex, science identity) predict student science self-efficacy?

1b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict student science self-efficacy?

1c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict student science self-efficacy?

2. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, percent White students in school, percent English language learners in school, percent of students on free and reduced lunch) predict student science self-efficacy?

3a. To what extent do a student’s person inputs (race, sex, science identity) predict a student’s STEM career intent?
3b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict a student’s STEM career intent?

3c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict a student’s STEM career intent?

4. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, percent White students in school, % English language learners in school, percent of students on free and reduced lunch) predict a student’s STEM career intent?

5. To what extent does the relationship between background contextual affordances and science self-efficacy vary by sex?

6. To what extent does the relationship between background contextual affordances and STEM career intent vary by sex?

**Data Collection**

**Source**

The High School Longitudinal Study of 2009 (HSLS: 09) was conducted by the National Center for Education Statistics in the fall term of the 2009-2010 school year (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). HSLS: 09 was sponsored by the National Center for Education Statistics (NCES) of the Institute of Education Sciences, U.S. Department of Education, with additional support from the National Science Foundation. The base-year study was conducted through a contract with RTI International, a university-
affiliated, nonprofit research organization in North Carolina, in collaboration with its subcontractors, the American Institutes for Research, Horizon Research, Windwalker, Research Support Services, and MPR Associates.

HSLS: 09 (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011) is the fifth study in the series of secondary longitudinal studies sponsored by the National Center for Education Statistics. The focus of the secondary longitudinal studies program is to study the educational development of students at various stages throughout their education and the contextual factors that may affect that development. Unlike the previous studies, HSLS:09 includes as an enhanced emphasis on STEM trajectories as well as documentation on science and math course placement and procedures. HSLS is a nationally representative sample of over 21,000 students who were 9th graders in the fall of 2009 from 940 schools that will be followed throughout their secondary and postsecondary years. The study focuses on understanding students’ trajectories from the beginning of high school into higher education and the workforce. The core research questions explore secondary to postsecondary transition plans, the paths into and out of science, technology, engineering, and mathematics (STEM) fields of study and careers, and the educational and social experiences that are related to shifts in plans or paths. Data for the base year, HSLS:09, were collected from students, math and science teachers, parents, school counselors and administrators from September 2009 to April 2010. Data were collected on students, parents, principals, math and science teachers, as well as the schools’ lead counselors via phone or web surveys.

Data Collection
Recruitment of school districts and schools began a year before data collection activities commenced by the organizations contracted by NCES (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). Once school approval was obtained, recruiters identified a school coordinator (SC) at each school to serve as a point of contact and to provide logistical information. The SC was responsible for scheduling the in-school sessions for data collection and identifying the appropriate staff members to complete the school administrator questionnaire and school counselor questionnaire. RTI developed a customized version of the Linux operating system, called Sojourn, to facilitate computer-based data collection, address concerns about data security, and ensure system compatibility across schools.

Student data collection was conducted in 940 high schools from September 8, 2009, through February 26, 2010, with telephone follow-up continuing through April 18, 2010 (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). Trained session administrators (SAs) conducted the in-school student sessions that gathered survey data and administered the math assessment to students. Special accommodations were provided to students with learning disabilities or a visual impairment. In-school sessions were conducted on school computers or laptop PCs provided by the project. Laptops were not connected to the Internet while in the schools, responses were stored directly on the laptop in encrypted files and the SAs securely transmitted the data after each in-school session.

**Sampling Procedures**

Survey responses for HSLS:09 were collected through a stratified, two-stage random sample design with primary sampling units defined as schools selected at the first stage and students randomly selected from the sampled schools within the second stage (Ingels, Herget,
Pratt, Dever, Copello, & Leinwand, 2011) as shown in Figures 3 and 4. A total of 940 schools out of 1,889 eligible schools participated in the base-year study resulting in a 55.5 percent weighted response rate (50.0 percent unweighted).

**Stage 1**

1. **Stratum 1 – School Type**
   
   (Public, private-Catholic, private –other)

2. **Stratum 2 – Region**
   
   (NE, MW, South, West)

3. **Stratum 3 – Locale**
   
   (city, suburban, rural, town)

4. **SCHOOLS**
   
   (944)

Figure 3. *Diagram of first stage sampling*
Selection of School Sample

The HSLS:09 base-year main study involved two state sampling: schools were the target population in stage 1, and students within schools were the target population in stage two (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). The target units selected in the first stage of sampling, were defined as regular public schools, including public charter schools, and private schools in the 50 United States and the District of Columbia providing instruction to students in both the 9th and 11th grades. Schools excluded from this definition (study-ineligible schools) include those that met any of the following criteria:
- Bureau of Indian Affairs (BIA) schools;
- Special education schools for students with disabilities;
- Career technical education (CTE) schools that do not enroll students directly;
- Department of Defense (DoD) schools located outside the United States (OCONUS);
- Schools without both a 9th and 11th grade;
- Schools not in operation during the fall of 2009;
- Juvenile correction/detention facilities;
- Other schools that address disciplinary issues but do not enroll students directly;
- Ungraded schools (i.e., no metric to define students as being in the ninth grade);
- Schools that only offer testing services for home-schooled students; and
- Schools that do not require students to attend daily classes at their facility.

The HSLS:09 sample schools were selected from two National Center for Education Statistics (NCES) files (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). The primary sample of regular public and public charter schools was selected from the 2005–06 Common Core of Data (CCD) and the private schools were sampled from the 2005–06 Private School Universe Survey (PSS). If the ninth-grade enrollment count was missing, the information was imputed using the median enrollment count for the corresponding sampling stratum (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). Within each first-stage stratum, samples were selected using Chromy’s 1981 sequential probability with minimum
replacement sampling algorithm. The composite measure of size was used in the sampling procedure was calculated as a linear combination of student counts multiplied by the desired overall sampling rates within race/ethnicity. A total of 48 mutually exclusive first-stage sampling strata were created for HSLS: 09. The strata were defined by cross-classification of three variables:

- School type or sector (public, private–Catholic, private–other);
- Region of the United States (Northeast, Midwest, South, West); and
- Locale (city, suburban, town, rural).

All study-eligible schools on the CCD were given a school type classification of public (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). A distinction between regular public and public charter schools was not made for the purposes of sampling. School type on the PSS was determined by whether the religious orientation/affiliation variable was set to “Roman Catholic.” All non-Catholic PSS private schools were classified in the private–other category. Within school type, the eligible schools were classified into four regions of the United States for the second stratification variable. The following assignments were made based on the FIPS state code associated with the physical location of the school:

- Northeast (CT, MA, ME, NH, NJ, NY, PA, RI, VT);
- Midwest (IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI);
- South (AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV);
- West (AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY).
The third stratification variable identified the locale (city, urban, town, rural) derived from previous NCES files (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). Prior to sample selection, the frame was additionally sorted to ensure a representative distribution across the United States and size of school. These strata were formed by cross-classifying the following nine U.S. Census divisions:

- New England/Middle Atlantic (CT, MA, ME, NH, NJ, NY, PA, RI, VT);
- East North Central (IL, IN, MI, OH, WI);
- West North Central (IA, KS, MN, MO, ND, NE, SD);
- South Atlantic (DC, DE, FL, GA, MD, NC, SC, VA, WV);
- East South Central (AL, KY, MS, TN);
- West South Central (AR, LA, OK, TX);
- Mountain (AZ, CO, ID, MT, NM, NV, UT, WY); and
- Pacific (AK, CA, HI, OR, WA).

The national design called for the selection of a sufficient sample to yield 800 eligible, participating schools—600 public schools, 100 Catholic schools, and 100 private–other schools (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). The proportion of schools dictated by the HSLS: 09 national design was similar for public and private schools—2.9 percent for both. Private–Catholic schools were oversampled (8.3 percent).

Sample

School and Student Demographics

National Center for Education Statistics (NCES) initially identified a sample of 1,890 eligible nationally representative schools, stratified on region (Northeast, Midwest, South,
West), locale (city, suburban, town, rural), and school type (public, private - Catholic, private - other private), with the target goal of achieving a sample of 940 schools (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). Out of 940 schools, 890 school administrators and 850 school counselors participated. A total of 26,310 students were sampled from these schools, for an average of 30 students per school, with 25,210 eligible. Of the 25,210 eligible sampled ninth-graders, 21,440 were questionnaire-completers, 550 were questionnaire-incapable, and 3,210 were non-respondents.

Of the 21,444 students that participated, the demographic/ethnicity representation was: 10,890 male (50.77%), 10,560 female (49.23%), 223 American Indian/Alaska Native (1.04%), 2,140 Asian/Pacific Islander (10.00%), 2,680 Black/Black (12.52%), 3,520 Hispanic (16.40%), 12,630 White (58.90%), 250 other race/more than one race/missing value (1.15%). A table of the student cohort demographics can be found on page 17 of the report *The High School Longitudinal Study of 2009 (HSLS:09): A First Look at Fall 2009 Ninth-Graders* (Ingels, Dalton, Holder, Lauff, & Burns, 2011).

**Instrumentation.** Base-year instrument design for HSLS:09 was guided by a theoretical framework or conceptual model (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). The model follows the influence of opportunities, supports and barriers on students’ values and expectations related to education and career goals and choices. The HSLS:09 design also acknowledges the importance of social context such as families, teachers, peers, and the wider community to students’ experiences.

**Student questionnaire.** The student questionnaire elicited demographic information (e.g., sex, race/ethnicity); language background; and school experiences in the current and
previous school year (including mathematics and science experiences and course enrollment). It also inquired into constructs such as math self-efficacy and identification and high school, postsecondary, and career plans, among other topics.

The student questionnaire was primarily self-administered using a computer during in-school sessions (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). If a student was unable to participate during the in-school sessions, a telephone interview was conducted using the same survey instrument with only the addition of interviewer instructions. Section A collected contact information in case there was an interruption during the telephone interview. Section B asked for the 9th-grader’s demographic information including sex, race/ethnicity, and birth date. The next section, Section C, collected information on the 9th-grader’s recent school experiences. Students were asked to indicate the school they attended in the previous school year (2008–09) and their grade level at that time. The 9th-graders also reported their involvement in various mathematics and science activities since the beginning of the previous school year. Finally, the students identified the mathematics and science courses they took in the 8th grade and the final grade they earned in each. Section D gathered data on self-efficacy in mathematics and identification as a mathematics person. In addition, a series of questions was posed about the mathematics course the 9th-grader was taking in the fall of 2009 and the teacher of that course. The name of the teacher that the school linked to the student was preloaded into the questionnaire. Section E repeated all of the same questions as Section D, but pertained to science instead of mathematics. Section F included questions on attitudes about school, mathematics, and science. Other questions focused on whom the student talks to about education, career plans, and personal problems;
friends’ attitudes about school and related behaviors; and programs in which the student had participated such as Upward Bound or MESA (Mathematics, Engineering, Science Achievement). Students were also asked to compare and evaluate males’ and females’ ability in mathematics, science, and English and language arts. This question was repeated on the parent and teacher questionnaires. Section G focused on high school, career, and college plans. Specifically, students were asked about their intentions to take further mathematics and science courses, if they had a career or college plan and who helped them create it, and their plans to take standardized college placement exams. In conclusion, they were asked how sure they were that they would graduate from high school. The final substantive section, Section H, collected data on educational expectations, plans for the year after high school, college plans, estimates of the cost of college, and the student’s expected occupation at age 30.

Parent questionnaire. The parent questionnaire covered household members and their roles and characteristics; demographic data; information on immigration status and language use; socioeconomic status (education, occupation, income); the student’s educational history (including grade retention and change of schools); family interactions; parental involvement in the ninth-grader’s learning; and plans and preparations for postsecondary education (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011).

Data collection staff asked that the parent or guardian most familiar with the 9th-grader’s school situation and experience complete the parent questionnaire (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). There were seven sections of the parent interview. Section A collected information about the residents of the 9th-grader’s household
including the presence of parents or guardians in the household, their relationship to the 9th-grader, and their marital status. Sections B and C collected data on the parents or guardians in the household. Section B collected data on race and ethnicity, immigration status, and language use. Race/ethnicity and immigration status were collected for both parents if there were two parents in the household. Parents were asked for the country in which the student was born, when he or she came to the United States if born elsewhere, and in what grade he or she was placed upon arrival. The next section, Section C, gathered information on the socioeconomic status of the 9th-grader’s parents. Each parent’s educational attainment, employment status, and current or most recent occupation was collected. Household income and home ownership were also ascertained. Section D focused on the student’s educational history including skipping or repeating grades, changing schools, dropout episodes, and suspensions and expulsions. In addition, data were collected on disabilities, special education services, enrollment in honors courses, and the frequency of contact from the school about problematic behavior, attendance, or performance. Section E measured parents’ involvement in the 9th-grader’s education and learning. Questions pertained to school selection, participation in school meetings and events, and helping with homework. In addition, parents were asked about activities the 9th-grader had engaged in outside of school and with a family member. Parents were also asked to compare and evaluate males’ and females’ ability in mathematics, science, and English and language arts. Questions in Section F pertained to the 9th-grader’s plans and preparations for postsecondary education. Parents were asked how far in school they hoped their 9th-grader would go, how far they anticipated they would actually go, and if they had spoken with someone knowledgeable
about the requirement for admission to a postsecondary institution. The final section of the interview, Section G, collected contact information for parents, relatives, and friends who can locate the 9th-grader in subsequent rounds of the study. It also collected data on parents’ education level, occupation, and income for constructing the socioeconomic status measure.

**School administrator questionnaire.** The school questionnaire allowed for two respondents: the factual information sections (1–4) could be delegated to a knowledgeable staff member, but the final section was to be completed only by the principal, because its content concerned the principal’s background and beliefs. The questionnaire elicited information about school characteristics; the student population; the school’s teachers; course offered; and the goals, beliefs, and background of the principal.

The school administrator questionnaire consisted of five sections. The first four asked factual questions about the school that could be completed by the principal or another knowledgeable individual on the school’s staff. The school administrator was the only appropriate respondent for the final section, however, because it asked background and subjective questions. Section A collected data on a range of topics such as the school’s grade span, control (public or private), type (e.g., charter, magnet, single sex, religious), academic calendar, and course scheduling. Another series of questions focused on schools identified as in need of improvement based on Adequate Yearly Progress requirements of No Child Left Behind. Section A concluded with questions about efforts the school had made to increase students’ interest in mathematics and science and to help struggling students. Section B gathered information on the student body, including their racial makeup, the percentage of 9th-grade students who were repeating 9th grade, the percentage of the 2008–09 9th-grade
class that returned to the school for the 2009–10 academic year, and the pursuits of the 2009 senior class. Section C collected information on the school’s faculty, with particular emphasis on mathematics and science teachers. Respondents reported the number of full- and part-time teachers in mathematics, science, and all other subjects. The number of mathematics and science teachers certified by the state to teach in their respective subject areas was also collected. Section D collected data on the mathematics and science curriculum. Requested information included the mathematics and science courses offered on- and off-site, whether completion of particular mathematics or sciences courses is required to graduate, whether these required courses are the same as or more advanced than state requirements, and whether students are placed in different algebra I courses based on ability. The final section, Section E, included questions about the school administrator’s background and his or her evaluation of the school’s problems. Requested information included the administrator’s demographic characteristics, educational and occupational history including years of experience as a school administrator and teacher, and certification.

**Variables**

The variables chosen for this study were selected based on their alignment with Lent, Brown and Hackett’s (1994) SCCT framework and the literature on the factors that influence science self-efficacy and STEM career intent in adolescents. Table 1 specifies the variables used from the dataset (note, as explained in later sections some of the variables have been re-coded, transformed and re-classified ). Descriptions of the variables, their meaning, and how they were coded for this study follows.
Table 1
Variables Used from HSLS:09

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student Level</strong></td>
<td></td>
</tr>
<tr>
<td>X1Black</td>
<td>9th grader is Black</td>
</tr>
<tr>
<td>X1Asian</td>
<td>9th grader is Asian</td>
</tr>
<tr>
<td>X1Hispanic</td>
<td>9th grader is Hispanic/Latino/Latina</td>
</tr>
<tr>
<td>X1AMINDIAN</td>
<td>9th grader is American Indian or Native Alaskan</td>
</tr>
<tr>
<td>X1PACISLE</td>
<td>9th grader is Hawaiian or Pacific Islander</td>
</tr>
<tr>
<td>X1SEX</td>
<td>9th grader’s sex</td>
</tr>
<tr>
<td>X1SCIID</td>
<td>Scale of science identity</td>
</tr>
<tr>
<td>X1SES</td>
<td>Scale of socioeconomic status</td>
</tr>
<tr>
<td>S1CLUB</td>
<td>Participated in a science club in the past year</td>
</tr>
<tr>
<td>S1COMPETE</td>
<td>Participated in a science competition in the past year</td>
</tr>
<tr>
<td>S1SCAMP</td>
<td>Participated in a science camp in the past year</td>
</tr>
<tr>
<td>S1STUTOR</td>
<td>Participated in science tutoring in the past year</td>
</tr>
<tr>
<td>S1SMUSEUM</td>
<td>Attended a science museum in the past year</td>
</tr>
<tr>
<td>S1TALENTSRCH</td>
<td>9th grader is participating in Talent Search</td>
</tr>
<tr>
<td>S1UPWARD</td>
<td>9th grader is participating in Upward Bound</td>
</tr>
<tr>
<td>S1GEARUP</td>
<td>9th grader is participating in GearUp</td>
</tr>
<tr>
<td>S1AVID</td>
<td>9th grader is participating in AVID</td>
</tr>
<tr>
<td>S1MESA</td>
<td>9th grader is participating in MESA</td>
</tr>
<tr>
<td>P1CAMPS</td>
<td>Parent took their 9th grader to a science camp in the last year</td>
</tr>
<tr>
<td>P1MUSEUM</td>
<td>Parent took their 9th grader to a science museum in the last year</td>
</tr>
<tr>
<td>P1SCIFAIR</td>
<td>Parent took their 9th grader to a science fair in the last year</td>
</tr>
<tr>
<td>P1SCIPROJ</td>
<td>Parent helped their 9th grader with a science project in the last year</td>
</tr>
<tr>
<td>P1SCISTEMDISC</td>
<td>Parent had a STEM career discussion with their 9th grader in the last year</td>
</tr>
<tr>
<td>P1SCIHWEFF</td>
<td>Parental science homework self-efficacy</td>
</tr>
<tr>
<td>S1TEPOPULAR</td>
<td>Engaging in science related activities will make 9th grader less popular</td>
</tr>
<tr>
<td>S1TEMMAKEFUN</td>
<td>Engaging in science related activities will cause 9th grader to be made fun of</td>
</tr>
<tr>
<td>S1TEFRNDS</td>
<td>Engaging in science related activities means 9th grader will have less time with friends</td>
</tr>
<tr>
<td>S1TEACTIV</td>
<td>Engaging in science related activities means 9th grader will have less time for other activities</td>
</tr>
<tr>
<td>W1STUDENT</td>
<td>Student Weight</td>
</tr>
<tr>
<td><strong>School Level</strong></td>
<td></td>
</tr>
<tr>
<td>X1CONTROL</td>
<td>School type</td>
</tr>
<tr>
<td>X1LOCALE</td>
<td>School locale</td>
</tr>
<tr>
<td>A1FREELUNCH</td>
<td>% of student body on free or reduced lunch</td>
</tr>
<tr>
<td>A1ELL</td>
<td>% of student body that are English Language Learners</td>
</tr>
<tr>
<td>A1White</td>
<td>% of student body that is White</td>
</tr>
</tbody>
</table>
Outcome Variables

**Student Science Self-Efficacy.** The student science self-efficacy scale (X1SCIEFF) is a composite variable that measured four science self-efficacy constructs represented by four variables: S1STESTS, S1STEXTBOOK, S1SSKILLS, S1SASSEXCL (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). Higher X1SCIEFF values represent higher science self-efficacy. The composite variable was created through principal components factor analysis (weighted by W1STUDENT) and standardized to a mean of 0 and standard deviation of 1. Only respondents who provided a full set of responses were assigned a scale value. If the student indicated that he or she was not taking a fall science class, this variable was set to -7. Values of -7 (item legitimate skip/NA), -8 (unit nonresponse/component not applicable), and -9 (missing) were re-coded as system missing. The coefficient of reliability for the scale was determined from item reliability analysis of the 4 variables that comprise the scale and the Chronbach’s alpha was determined to be 0.88. Following are descriptions of the four science self-efficacy variables that comprise the composite scale:

**S1STESTS** – The 9th grader is confident that he/she can do an excellent job on Fall 2009 science tests.

**S1STEXTBOOK** – The 9th grader is certain he/she can understand the science textbook.

**S1SSKILLS** – The 9th grader is certain he/she can master skills in Fall 2009 science courses.

**S1SASSEXCL** – The 9th grader is confident that he/she can do an excellent job on Fall 2009 science assignments.

Student STEM Career Intent by Age 30. X1STU30OCC2 is the variable that measured student STEM career intent by the age of 30 (Ingels, Herget, Pratt, Dever, Copello,
Careers were categorized based on the 2-digit Occupational Information Network (O*NET) code. O*NET is the nation’s primary source of occupational information. It is sponsored by the US Department of Labor/Employment and Training Administration. Since this variable includes careers that are non-STEM related, it was re-coded to include only those careers that are considered related to STEM fields based on the O*NET taxonomy database and prevailing definitions of STEM. The National Science Foundation (NSF, 2012) was used as the predominant definer of STEM occupations. Based on the NSF definition, careers that includes chemistry, computer and information science, engineering, physical sciences (math, physics), life sciences (biology related), architecture, and geosciences. While the NSF utilizes a broader definition of STEM and also includes business related and legal occupations for the administration of their STEM related grants, the following categories: management occupations (code 11), business and financial operations (code 13), and legal occupations (code 23), were not included in this study as a STEM career based on the body of empirical literature regarding science and engineering related occupations. The majority of the studies regarding STEM careers do not include business or legal occupations, and therefore they are not considered in this study. The following 2-digit coded occupations were included as indicative of STEM careers: Occupation code 15 = computer/math, Occupation code 17 = architecture and engineering, and Occupation code 19 = life, physical and social sciences. Each of these STEM occupation codes will be recoded as “1” indicating that the 9th grader intends to be engaged in a STEM career by age 30 and coded as “0” if none of these occupations are chosen by the 9th grader. The following 2-digit coded occupations will be considered non-STEM related and excluded from the study:
Code    Occupation
11    Management Occupations
13    Business and Financial Operations Occupations
21    Community and Social Services Occupations
23    Legal Occupations
25    Education, Training, and Library Occupations
27    Arts, Design, Entertainment, Sports, and Media Occupations
29    Healthcare Practitioners and Technical Occupations
31    Healthcare Support Occupations
33    Protective Service Occupations
35    Food Preparation and Serving Related Occupations
39    Personal Care and Service Occupations
41    Sales and Related Occupations
45    Farming, Fishing, and Forestry Occupations
47    Construction and Extraction Occupations
49    Installation, Maintenance, and Repair Occupations
51    Production Occupations
53    Transportation and Material Moving Occupations
55    Military Specific Occupations

**Predictor Variables (Student level data)**

**Person Inputs.** Consistent with the SCCT theoretical model of student career choice, several person input variables were included in this study. Level-1 data assesses student demographic characteristics such as race (X1Black, X1Asian, X1Hispanic, AMINDIAN, X1PACISLE) and sex (X1SEX), as well as predispositions like science identity (X1SCIID).
**Race/ethnicity.** The variables that denote a student’s race and ethnicity were included in the model and include X1Black, X1Hispanic, X1Asian, X1Native Alaskan/American Indian, and X1Hawaiian/Pacific Islander. X1White was left out of the model because it serves as the reference group. Individual race/ethnicity categories were re-coded using dummy variables to indicate a specific race (1 = yes and 0 = no).

**Sex.** The variable X1SEX characterizes the student’s sex (male = 1, female = 2). The sex of the sample member was taken from the base year student questionnaire, parent questionnaire, and/or school-provided sampling roster. If the sex indicated by any of these three sources was inconsistent, X1SEX was coded based on manual review of the sample member's first name. For the purposes of this study, any regression results have males as the reference group.

**Science Identity.** This composite scale (X1SCIID) is composed of two variables that represent the construct of science identity (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). It refers to whether or not the 9th grader sees himself/herself as a science person (S1SPERSON1) or if others see the 9th grader as a science person (S1SPERSON2). Higher X1SCIID values correspond to higher science identity. The scale was created through principal components factor analysis (weighted by W1STUDENT) and standardized to a mean of 0 and standard deviation of 1. Only respondents who provided a full set of responses were assigned a scale value. Values of -7 (item legitimate skip/NA), -8 (unit nonresponse/component not applicable), and -9 (missing) were re-coded as system missing. The coefficient of reliability (alpha) for the scale is .65. I included the science identify composite variable in this study based on the work of Carlone (2007) that suggests science
identity may influence student interest and attitudes about science, as well as confidence in science and future science career intent.

**Background contextual affordances.** Also consistent with the SCCT model (Lent, Brown, & Hackett, 1994) are the influence of background contextual affordances of the student’s immediate environment such as socioeconomic status (SES) and parental support. As such, variables representing students’ SES and overall parental support regarding science and math were included in this study.

**SES.** X1SES is a composite variable that characterizes student socio-economic status and is comprised of five component variables that include parent/guardians’ education (X1PAR1EDU and X1PAR2EDU), occupation (X1PAR1OCC2 and X1PAR2OCC2), and family income (X1FAMINCOME) (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). For cases with nonresponding parent/guardians, 5 imputed values are generated (X1SES1-X1SES5), X1SES is computed as the average of the 5 imputed values, and the imputation flag is set as X1SES_IM=1 (values for parent/guardian education, occupation, and income are set to -8). When education, occupation, or family income are imputed using other information provided by the responding parent/guardian, X1SES is constructed from the combination of actual and imputed parent/guardian values. For these cases, the values of X1SES1-X1SES5 are equivalent to X1SES and X1SES_IM=2. Otherwise, the responding parent/guardian provided responses for all input variables so that the values of X1SES1-X1SES5 are again equivalent to X1SES and X1SES_IM=0.

**Parental Support.** I created a composite variable for parental support (Parental Support) was created from the following variables: (PICAMPMS, P1MUSEUM,
P1SCIFAIR, P1SCIPROJ, P1SCISTEMDISC) that measured parental participation in math/science camps such as, taking their 9th grader to a science museum, helping their 9th grader with a science fair project, helping their 9th grader with a school science project, and discussing science with their 9th grader. This variable was coded 0 = no participation, 1 = at least one activity, and 2 = more than one activity. The variable was recoded into dummy variables (0 = no, 1 = yes) to represent each of the three categories. Participating in at least one activity was the reference group.

Parental self-efficacy regarding helping their 9th grader with science homework (P1SCIHWEFF) was also included in the model. This variable was originally coded as: 1 = very confident, 2 = somewhat confident and 3 = not at all confident. It was re-coded using dummy variables (0 = yes, 1 = no) to represent each of the three original codes. These parental support variables were be included in the model based on the literature that suggests parental support is a key factor in encouraging students to pursue STEM careers and improving science self-efficacy. Being not confident at all was the reference group.

Informal Learning experiences.

Extracurricular Science Learning Experiences. The SCCT model (Lent, Brown & Hackett, 1994) suggests that learning experiences have a significant influence on both self-efficacy and career intent. For this study, learning experiences included participation in extracurricular science activities (outside of the science classroom) and participating in outreach programs that are not specifically targeted towards STEM, but often have math and science components. A composite variable was created to represent student extracurricular learning experiences (X1ECLRNEXP). It was comprised of students’ responses to survey
items that asked them whether or not they had participated in a science club (S1SCLUB), science competition (S1SCOMPETE), science camp (S1SCAMP), science tutoring (S1STUTOR), or attended a science museum (S1SMUSEUM). This variable was coded 0 = no participation, 1 = at least one activity, and 2 = more than one activity. The variable was re-coded using dummy variables (0 = yes, 1 = no) to represent each of the three original codes.

**Outreach Programs.** I created a composite variable for participation in outreach programs (XIOUTREACH) that included Talent Search (S1TALENTSRCH), Upward Bound (S1UPWARD), GearUp (S1GEARUP), AVID (S1AVID), and MESA (S1MESA). This variable was coded 0 = no participation, 1 = at least one activity, and 2 = more than one activity. The variable was re-coded using dummy variables (0 = yes, 1 = no) to represent each of the three categories. Participating in at least one program was the reference group. Talent Search, Upward Bound, GearUp and AVID are each part of a cadre of programs sponsored by the U.S. Department of Education whose mission is to increase college readiness. These programs identify and assist students from underserved and low income backgrounds who have the potential to succeed in secondary and postsecondary education. The MESA program is the only one out of the group that has a specific focus on math, science and engineering. However, all of the programs have some type of math and science related components such as tutoring and career awareness.

**Outcome expectations.** I created a composite variable to represent outcome expectations based on the SCCT model (Lent, Brown, & Hackett, 1994). The SCCT model defines outcome expectations as the motivation to either participate or not participate in
specific activities based on expected outcomes. In essence, students will participate in science related activities based on their expectations of what will happen as a result of participating. This composite variable is composed of the following four variables: 1) SITEFRNDS, which refers to the 9th graders’ expectation that time and effort spent on science and math related activities will mean less time for friends, 2) SITEACTIV, which refers to the 9th graders’ expectation that time and effort spent on science and math related activities will mean not enough time for extracurricular activities, 3) SITEPOPULAR, which refers to the 9th graders’ expectation that time and effort spent on science and math related activities will mean they will not be popular, and 4) SITEMAKEFUN, which refers to the 9th graders’ expectation that time and effort spent on science and math related activities will cause them to be made fun of. The original order of the Likert scale (1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree) was kept and results are interpreted as the higher the score, the more positive the student view on outcome expectations (i.e., the student disagrees that participating in science/math activities will negatively impact them).

**Predictor Variables (School Level Data)**

*Contextual influences proximal to career choice.* Additional variables at level 2 were included in this study and identified as Contextual Influences Proximal to Choice Behavior based on the SCCT model (Lent, Brown, & Hackett, 1994). These variables are consistent with characteristics of the student’s context during the high school years and when students start to make career choices. These school level variables were included in the HLM analysis in order to determine how students in different school environments (type and locale) and in schools with different demographic characteristics (percent White, percent
free/reduced lunch, percent ELL), may relate to students’ science self-efficacy and STEM career intent. Schools’ race/ethnicity and economic profiles have been shown to be a significant influence on school resources and whether or not students receive a quality education, especially as it relates to science (Russell & Atwater, 2005).

**Percent free/reduced lunch.** The continuous variable A1FREELUNCH represents the percent of students on free and/or reduced lunch in a school and is an indicator of SES.

**Percent White.** The continuous variable A1WHITE represents the percent of the student population in a school that is classified as White.

**English Language Learners.** This continuous variable represents the percent of the students in the school that were English language learners.

**School type.** The variable X1CONTROL represents the school’s classification as public, Catholic or private-other. This variable was originally coded as 1 = public, 2 = catholic, and 3 = other private. The variable was re-coded using dummy variables (0 = yes, 1 = no) to represent each of the three codes. Public schools were used as the reference group in the HLM analyses.

**Locale.** The variable X1LOCALE represents the metropolitan area that the school resides and will provide insight into the location, environment and population that surrounds the school. School locale was originally coded as 1 = city, 2 = suburban, 3 = town, and 4 = rural. The variable was re-coded using dummy variables (0 = yes, 1 = no) to represent each of the four codes. Suburban was used as the reference group in the HLM analyses.
Data Management

Since the school level variables were restricted in the base year file, security clearance had to be obtained from the National Center for Education Statistics. Once the clearance was approved, the data was sent on a CD. An office was prepared that met security clearance requirements in order to conduct the analyses. The secure office space included a secure computer to house the data and locked file cabinet to house the CD. The secure computer was not networked to a printer or the internet, in accordance with security procedures. All data manipulation and analyses were conducted on the secure computer and accessed with a password that only the researcher and research advisor knew.

Analysis

Missing Value Analysis and Multiple Imputation

Missing Value Analysis was conducted using SPSS version 21.0 in order to determine if there were missing data, where the missing data were located, and if there was a pattern to the missing data. Missing data can be a problem in statistical analyses for two reasons. First, if the cases of missing values differ systematically from complete cases, then the results can be misleading (Little & Rubin, 1987). Second, inferential statistics are based on complete sets of data, and having missing values can reduce the overall precision of the analyses because less information is available. Little’s MCAR test was conducted using SPSS version 21.0. This test determines if the data is missing completely at random, or not missing completely at random. The threshold for missing values is at least 10%. The results of the missing value analysis indicated that the following variables were found not to be
missing completely at random: X1SES, X1SCIID, X1SCIEFF, percent free/reduced lunch, percent ELL, percent White and parental science homework self-efficacy.

Based on the results of the missing value analysis, multiple imputation was employed using SPSS in order to fill in the missing values. In multiple imputation, missing values are predicted or “imputed” using the existing values from the other variables (Graham & Hofer, 2000). Five imputations were performed, with 100 iterations in each imputation. The student weight was used as a variable in SPSS to create quintiles to perform the multiple imputation. Each of the five categories of equal size in the student weight distribution served as the cut points for the quintiles. All analyses were run with and without imputed data and compared. There were no substantial differences in the magnitude of the coefficients or whether it was statistically significant.

**Multicollinearity Diagnostics**

Multicollinearity diagnostics were also conducted to determine the intercorrelations among the predictor variables. If there are variables in the study that are highly correlated to each other it will lead to unstable regression estimates and variance parameters (Kumar, 1975). Collinearity diagnostics were performed using SPSS and three main criteria were evaluated based on Belsley, Kuh and Welsch’s (1980) protocol: the eigenvalue, the VIF, and the condition number. If any of the following conditions were met, then there could potentially be a collinearity concern: 1) A VIF greater than 10, or 2) an eigenvalue (EV) close to “0”, or a condition index greater than 15. The results for the science self-efficacy model indicated that parent science homework self-efficacy (somewhat confident) had an EV of 0.015 and a condition index of 22.508, suggesting that this variable may be highly
correlated with science self-efficacy. For the STEM career intent model, the results indicated that two variables, science self-efficacy (EV = 0.037, condition index = 15.325) and outcome expectations (EV = 0.010, condition index = 29.436) may be highly correlated to STEM career intent.

Hierarchical Linear Modeling

Hierarchical Linear Modeling (HLM) was employed to determine the effect of holding one level of variables constant, while analyzing a second level. HLM is particularly useful when analyzing data that has multiple levels (Raudenbush & Bryk, 2002). Generally, HLM is employed where individuals are the main unit of interest at lower levels, but are “nested” within contextual structures, such as schools, that are the main unit of analysis at higher levels (Fidell & Tabachnick, 2007). For this dataset, since students are nested schools, using OLS regression would violate the criterion of independent observations (Figure 5). Clustering of observations within groups or hierarchies leads to correlated error and biased estimates of parameter standard errors when not accounted for (Raudenbush & Bryk, 2002). Additionally, variance parameters that provide insight into model fit can be biased if standard multiple regression is employed for nested data (Snijders & Bosker, 2011).
HLM allows researchers to explore predictor variables that are measured at more than one level and where the observations are related in a hierarchical fashion. HLM is a regression-based procedure that has been typically associated with education research (Raudenbush & Bryk 2002). This study used a null, or “unconditional,” model containing no independent variables to predict the level 1 (student characteristics—race, sex, SES, contextual variables) intercept of science self-efficacy and STEM career intent as a random effect of students. The null model was then compared to a random effects model which contained only level-1 variables and an intercepts-as-outcomes model, which contained level-1 (student characteristics—race, sex, SES, contextual variables) and level-2 (school ID). Analyses were run with and without the student weight. Weighting is often employed in large samples of survey data that involve stratified or clustered sample designs. Weighting accounts for the fact the samples are not drawn completely at random and in order to produce unbiased estimates for the actual population. The student weight (W1STUDENT) for this sample is composed of a base weight that incorporates four student race/ethnicity categories.
(Black, Hispanic, Asian, and other), as well as two nonresponse adjustments and a final calibration (Ingels, Herget, Pratt, Dever, Copello, & Leinwand, 2011). HLM analyses were performed by group centering continuous variables at level 1 and grand centering continuous variables at level 2.

**Model Specification**

To explain the variance associated with student science self-efficacy, this study used a two-level intercept-as-outcomes hierarchical model. The dependent variables science self-efficacy and STEM career intent were contained in the first order model. The intercepts in the first order model were derived from the slopes and error term from the level-2 model. The equations below illustrate the fully specified HLM model for predicting science self-efficacy and the hierarchical logistic model for predicting STEM career intent that was used to assess the impact of student-level effects (student characteristics–race, sex, SES, contextual variables) and school-level (school ID).

**Science Self-Efficacy Fully Unconditional Model (Null)**

\[
X_{1SCIEFF}_{ij} = \gamma_{00} + u_{0j} + r_{ij}
\]

Where:  
\(\beta_{0j} = \gamma_{00} + u_{0j}\),

\(X_{1SCIEFF}_{ij}\) = confidence for student i and school j,

\(\beta_{0j}\) = mean confidence rating for student i

\(\gamma_{00}\) = grand mean for all science self-efficacy

\(u_{0j}\) = random effect associated with school j (level-2 effect)

\(r_{ij}\) = random effect associated with student i in school j (level-1 effect)
Science Self-Efficacy Random Effects Model

\[ X1\text{Science self efficacy}_i = \gamma_{00} \]
\[ + \gamma_{10} * X1\text{SES}_i \]
\[ + \gamma_{20} * X1\text{science identity}_i \]
\[ + \gamma_{30} * X1\text{sex}_i \]
\[ + \gamma_{40} * X1\text{hispanic}_i \]
\[ + \gamma_{50} * X1\text{black}_i \]
\[ + \gamma_{60} * X1\text{Asian}_i \]
\[ + \gamma_{70} * X1\text{Hawaiian/Pacific Islander}_i \]
\[ + \gamma_{80} * X1\text{American Indian/Native Alaskan}_i \]
\[ + \gamma_{90} * extracurricular science - \text{none}_A_i \]
\[ + \gamma_{100} * \text{extracurricular science – more than one }_A_i \]
\[ + \gamma_{110} * \text{parental science homework self-efficacy – very confident}_i \]
\[ + \gamma_{120} * \text{parental science homework self-efficacy – somewhat confident}_i \]
\[ + \gamma_{130} * \text{outreach programs - none}_A_i \]
\[ + \gamma_{140} * \text{outreach programs more than one }_A_i \]
\[ + \gamma_{150} * \text{parental support - none}_j \]
\[ + \gamma_{160} * \text{parental support – more than one}_j \]
\[ + u_{0j} + r_{ij} \]

Where: \( \beta_{0j} = \gamma_{00} + u_{0j} \), \( \beta_{1j} = \gamma_{10} + u_{1j} \), \( \beta_{2j} = \gamma_{20} + u_{2j} \), \( \beta_{3j} = \gamma_{30} + u_{3j} \)

\( \beta_{1j} - \beta_{3j} \) = regression coefficients indicating how the science self-efficacy is distributed in (school) \( j \) as a function of the measured student characteristic

\( \gamma_{00} \) = average intercept across the level-2 units

\( \gamma_{10-30} \) = average regression slope across the level-2 units

\( u_{0j} \) = unique increment to the intercept associated with (school) \( j \)

\( u_{1j-3j} \) = unique increment to the slope associated with (school) \( j \)

Science Self-Efficacy Random Effects with Interaction

\[ X1\text{SCIEFF}_i = \gamma_{00} \]
\[ + \gamma_{10} * X1\text{SES}_i \]

87
\[ + \gamma_{20} \cdot X_{1 \text{science identity}}_{ij} \\
+ \gamma_{30} \cdot X_{1 \text{sex}}_{ij} \\
+ \gamma_{40} \cdot X_{1 \text{hispanic}}_{ij} \\
+ \gamma_{50} \cdot X_{1 \text{Black}}_{ij} \\
+ \gamma_{60} \cdot X_{1 \text{Asian}}_{ij} \\
+ \gamma_{70} \cdot X_{1 \text{Hawaiian/Pacific Islander}}_{ij} \\
+ \gamma_{80} \cdot X_{1 \text{American Indian/Native Alaskan}}_{ij} \\
+ \gamma_{90} \cdot \text{extracurricular science - none}_{A_{ij}} \\
+ \gamma_{100} \cdot \text{extracurricular science - more than one}_{A_{ij}} \\
+ \gamma_{110} \cdot \text{parental science homework self-efficacy - very confident}_{ij} \\
+ \gamma_{120} \cdot \text{parental science homework self-efficacy - somewhat confident}_{ij} \\
+ \gamma_{130} \cdot \text{Sex X Parental support}_{ij} \\
+ \gamma_{140} \cdot \text{Sex X SES}_{ij} \\
+ \gamma_{150} \cdot \text{outreach programs - none}_{A_{ij}} \\
+ \gamma_{160} \cdot \text{outreach programs - more than one}_{A_{ij}} \\
+ \gamma_{170} \cdot \text{parental support - none}_{ij} \\
+ \gamma_{180} \cdot \text{parental support - more than one}_{ij} \\
+ u_{0j} + r_{ij} \]

**Science Self-Efficacy Intercepts-As-Outcomes Model**

\[ X_{1 \text{SCIEFF}}_{ij} = \gamma_{00} + \gamma_{01} \cdot A_{1 \text{FREELU}}_{j} + \gamma_{02} \cdot A_{1 \text{ELL}}_{j} + \gamma_{03} \cdot A_{1 \text{WHITES}}_{j} + \gamma_{04} \cdot \text{city}_{j} + \gamma_{05} \cdot \text{town}_{j} + \gamma_{06} \cdot \text{rural}_{j} + \gamma_{07} \cdot \text{catholic}_{A_{j}} + \gamma_{08} \cdot \text{other private}_{A_{j}} \]
\[ + \gamma_{10} \cdot X1SES_{ij} \]
\[ + \gamma_{20} \cdot X1science\text{ identity}_{ij} \]
\[ + \gamma_{30} \cdot X1sex_{ij} \]
\[ + \gamma_{40} \cdot X1Hispanic_{ij} \]
\[ + \gamma_{50} \cdot X1Black_{ij} \]
\[ + \gamma_{60} \cdot X1Asian_{ij} \]
\[ + \gamma_{70} \cdot X1Hawaiian/Pacific Islander_{ij} \]
\[ + \gamma_{80} \cdot X1American\text{ Indian/Native Alaskan}_{ij} \]
\[ + \gamma_{90} \cdot extracurricular\text{ science - none}_A_{ij} \]
\[ + \gamma_{100} \cdot extracurricular\text{ science - none}_A_{ij} \]
\[ + \gamma_{110} \cdot parent\text{ science homework self-efficacy – very confident}_{ij} \]
\[ + \gamma_{120} \cdot parent\text{ science homework self-efficacy – somewhat confident}_{ij} \]
\[ + \gamma_{130} \cdot outreach\text{ programs - none}_A_{ij} \]
\[ + \gamma_{140} \cdot outreach\text{ programs - more than one}_A_{ij} \]
\[ + \gamma_{150} \cdot parental\text{ support - none}_{ij} \]
\[ + \gamma_{160} \cdot parental\text{ support – more than one}_{ij} \]
\[ + u_{0j} + r_{ij} \]

Where  \( \beta_{0j} = \gamma_{00} + \gamma_{01}(\%\text{ free lunch})_j + \gamma_{02}(\%\text{ ELL})_j + \gamma_{03}(\%\text{ White})_j + \gamma_{04}(\text{locale-city})_j + \gamma_{05}(\text{locale-town})_j + \gamma_{06}(\text{locale-rural})_j + \gamma_{07}(\text{Catholic})_j + \gamma_{08}(\text{other private})_j + u_{0j} \)

\( \beta_{ij} = \gamma_{10} + u_{1j} \)

\( \gamma_{00} \): average intercept across the level-2 units

\( \gamma_{01} - \gamma_{09} \): average slope across level-2 units
\( \gamma_{10-30}: \) average regression slope across the level-2 units

\( u_{0j}: \) unique increment to the intercept associated with (school) j

\( u_{ij-3j}: \) unique increment to the slope associated with (school) j

RQ 3a, 3b, and 3c

**STEM Career Intent Fully Unconditional Model (Null)**

\[
\text{Prob}(X1STU30O_{ij}=1|\beta_j) = \phi_{ij}
\]

\[
\log[\phi_{ij}/(1 - \phi_{ij})] = \eta_{ij}
\]

\( \eta_{ij} = \beta_{0j} \)

\( X1STU30OCC2_{ij} = \beta_{0j} + r_{ij} \)

Where: \( \beta_{0j} = \gamma_{00} + u_{0j}, \)

\( X1STU30OCC2_{ij} = \) STEM career intent for student i and school j,

\( \beta_{0j} = \) mean career intent rating for student i

\( \gamma_{00} = \) grand mean for all STEM career intent constructs

\( u_{0j} = \) random effect associated with school j (level-2 effect)

\( r_{ij} = \) random effect associated with student i in school j (level-1 effect)

**STEM Career Intent – Random Effects Model**

\[
\text{Prob}(X1STU30O_{ij}=1|\beta_j) = \phi_{ij}
\]

\[
\log[\phi_{ij}/(1 - \phi_{ij})] = \eta_{ij}
\]

\( \eta_{ij} = \beta_{0j} + \beta_{i1j}*(X1SES_{ij}) + \beta_{i2j}*(X1science~identity_{ij}) + \beta_{i3j}*(X1self~efficacy_{ij}) + \beta_{i4j}*(X1sex_{ij}) + \beta_{i5j}*(X1Hispanic_{ij}) + \beta_{i6j}*(X1Black_{ij}) + \beta_{i7j}*(X1Asian_{ij}) + \beta_{i8j}*(X1Hawaiian/Pacific~Islander_{ij}) + \beta_{i9j}*(X1American~Indian/Native~Alaskan_{ij}) + \beta_{i10j}*(outcome~expectations_{ij}) + \beta_{i11j}*(extracurricular~science~none_{A_{ij}}) + \beta_{i12j}*(extracurricular~science~more~than~one_{A_{ij}}) \)
+ $\beta_{1ij}*(\text{parental science homework self-efficacy very confident}_{ij}) + \beta_{14j}*(\text{parental science homework self-efficacy somewhat confident}_{ij}) + \beta_{15j}*(\text{outreach programs - none}_{Aij}) + \beta_{16j}*(\text{outreach programs - more than one}_{Aij}) + \beta_{17j}*(\text{parental support - none}_{ij}) + \beta_{18j}*(\text{parental support more than one}_{ij})$

Where: $\beta_{0j} = \gamma_{00} + u_{0j}, \beta_{1j} = \gamma_{10} + u_{1j}, \beta_{2j} = \gamma_{20} + u_{2j}, \beta_{3j} = \gamma_{30} + u_{3j}$

$\beta_{1j-3j}$ = regression coefficients indicating how STEM career intent is distributed in (school) $j$ as a function of the measured student characteristic

$\gamma_{00}$ = average intercept across the level-2 units

$\gamma_{10-30}$ = average regression slope across the level-2 units

$u_{0j}$ = unique increment to the intercept associated with (school) $j$

$u_{1j-3j}$ = unique increment to the slope associated with (school) $j$

**STEM Career Intent Intercepts as Slopes Model**

$\eta_{ij} = \gamma_{00} + \gamma_{01}*A1FREELU_{j} + \gamma_{02}*A1ELL_{j} + \gamma_{03}*A1WHITES_{j}$

$+ \gamma_{04}*\text{city}_{ij} + \gamma_{05}*\text{town}_{ij} + \gamma_{06}*\text{rural}_{ij} + \gamma_{07}*\text{catholic}_{Aij}$

$+ \gamma_{08}*\text{other private}_{Aij}$

$+ \gamma_{10}*\text{XISES}_{ij}$

$+ \gamma_{20}*\text{X1science identity}_{ij}$

$+ \gamma_{30}*\text{X1self efficacy}_{ij}$

$+ \gamma_{40}*\text{X1sex}_{ij}$

$+ \gamma_{50}*\text{X1HISPAN}_{ij}$

$+ \gamma_{60}*\text{X1BLACK}_{ij}$

$+ \gamma_{70}*\text{X1ASIAN}_{ij}$
\[ + \gamma_{80}^{\star}X_{I PACISL_{ij}} + \gamma_{90}^{\star}X_{I AMINDI_{ij}} + \gamma_{100}^{\star}\text{outcome expectations}_{ij} + \gamma_{110}^{\star}\text{extracurricular science - none}_{A_{ij}} + \gamma_{120}^{\star}\text{extracurricular science - more than one}_{A_{ij}} + \gamma_{130}^{\star}\text{parental science homework self-efficacy – very confident}_{ij} + \gamma_{140}^{\star}\text{parental science homework self-efficacy – somewhat confident}_{ij} + \gamma_{150}^{\star}\text{outreach programs - none}_{A_{ij}} + \gamma_{160}^{\star}\text{outreach programs – more than one}_{A_{ij}} + \gamma_{170}^{\star}\text{parental support - none}_{ij} + \gamma_{180}^{\star}\text{parental support – more than one}_{ij} + u_{0j} \]

**Chapter Summary**

Chapter III described the methodology, data collection, sample, and instrumentation, variables, and the specific statistical procedures that were used to address the research questions. Sampling procedures for the schools and students were also discussed in detail in addition to response rates for the participants and the surveys that were administered. A brief discussion of how each variable was operationalized was outlined as well. Lastly, a discussion of the statistical analyses and models was presented. Chapter IV presents the results of the quantitative analysis, and Chapter V will present the discussion and conclusions.
CHAPTER IV: RESULTS

The primary purpose of this study is to identify factors that predict science self-efficacy and STEM career intent for 9th graders, with special attention to how some factors’ relationships with science self-efficacy and STEM career intent vary by sex. The results from this work can be used to guide science education policy at the local, state, and national levels, and direct science education programming in formal and informal settings.

Chapter IV begins with a review of the purpose of the study followed by a description of the sample and then research questions that guide the study. Descriptive results are then presented and are followed by the results of the HLM analyses.

Using data from the High School Longitudinal Study of 2009 (HSLS:09), which gathered detailed information about a nationally representative sample of 21,440 9th graders from 940 schools, analyses were performed in order to determine what factors predicted student science self-efficacy and STEM career intent.

Research Questions

The research questions that guided this study were:

1a. To what extent do a student’s person inputs (race, sex, science identity) predict student science self-efficacy?

1b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict student science self-efficacy?

1c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict student science self-efficacy?
2. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, % White students in school, % English language learners in school, % of students on free and reduced lunch) predict student science self-efficacy?

3a. To what extent do a student’s person inputs (race, sex, science identity) predict a student’s STEM career intent?

3b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict a student’s STEM career intent?

3c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict a student’s STEM career intent?

4. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, % White students in school, % English language learners in school, % of students on free and reduced lunch) predict a student’s STEM career intent?

5. To what extent does the relationship between background contextual affordances (SES and parental support) and science self-efficacy vary by sex?

6. To what extent does the relationship between background contextual affordances (SES and parental support) and STEM career intent vary by sex?

**Descriptive Statistics**

Descriptive statistics are presented in Tables 2-3. Results for the student weighted sample are provided, including the maximum and minimum values, and the mean and standard deviations (continuous only) for each variable.
**Table 2**

*Descriptive Statistics for Student Level Variables-Student Weighted*

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<th>Mean</th>
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<th>Min</th>
<th>Max</th>
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<td>0.75</td>
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<td>1.00</td>
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<td>1.00</td>
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<td>1.00</td>
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<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
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<td>0.00</td>
<td>1.00</td>
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</tr>
<tr>
<td>American Indian/Native Alaskan</td>
<td>4103063</td>
<td>0.10</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Outcome Expectations</td>
<td>4012533</td>
<td>2.93</td>
<td>0.57</td>
<td>1.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Outreach Programs - none</td>
<td>3948557</td>
<td>0.87</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Outreach Programs – at least 1</td>
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<td>0.09</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Outreach Programs – more than 1</td>
<td>3948557</td>
<td>0.04</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Parental Support - none</td>
<td>2906437</td>
<td>0.16</td>
<td>0.00</td>
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<td>1.00</td>
</tr>
<tr>
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<td>0.28</td>
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<td>STEM Career Intent by Age 30</td>
<td>2821805</td>
<td>0.16</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td>Extracurricular Science Activities - None</td>
<td>4105851</td>
<td>0.74</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Extracurricular Science Activities – at least 1</td>
<td>4105851</td>
<td>0.23</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Extracurricular Science Activities – More than 1</td>
<td>4105851</td>
<td>0.03</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Parent Science Homework Self-Efficacy-Very Confident</td>
<td>2920547</td>
<td>0.38</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Parent Science Homework-Somewhat Confident</td>
<td>2920547</td>
<td>0.47</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Parent Science Homework Self-Efficacy-Not at all Confident</td>
<td>2920547</td>
<td>0.15</td>
<td>0.00</td>
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<td>1.00</td>
</tr>
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</table>
Table 3
*Descriptive Statistics for School Level Variables – Weighted*

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Free/Reduced Lunch</td>
<td>3828615</td>
<td>39.29</td>
<td>25.15</td>
<td>0.00</td>
<td>100.00</td>
</tr>
<tr>
<td>% ELL</td>
<td>3853120</td>
<td>6.27</td>
<td>10.27</td>
<td>0.00</td>
<td>76.00</td>
</tr>
<tr>
<td>% White</td>
<td>3867379</td>
<td>59.73</td>
<td>31.21</td>
<td>0.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Locale 1 - City</td>
<td>4197724</td>
<td>0.32</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Locale 2 - Suburb</td>
<td>4197724</td>
<td>0.33</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Locale 3 - Town</td>
<td>4197724</td>
<td>0.12</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Locale 4 - Rural</td>
<td>4197724</td>
<td>0.23</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
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<tr>
<td>Public</td>
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<td>0.93</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Catholic</td>
<td>4197724</td>
<td>0.04</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Other private</td>
<td>4197724</td>
<td>0.03</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

**Level 1 Variables (Student)**

Student variables were entered into the model at level 1 in order to predict the outcome variable science self-efficacy. Level 1 variables contribute to our understanding of the variance within schools, which reflect differences among the individual students. The following section describes level 1 variable characteristics.

**SES.** SES is a continuous composite variable that measured the student’s socioeconomic status using information compiled from their parent’s income, education, and occupation. The values for this variable ranged from -1.93 to 2.88, with a mean of -0.08 and a standard deviation of 0.75.

**Science identity.** Science identity is a continuous composite scale that represents the student’s belief about whether or not they and others see themselves as a science person. The values for this variable ranged from -1.57 to 2.15, with a mean of 0.00, and a standard deviation of 1.00.
Science self-efficacy. Science self-efficacy is the outcome variable for this study. It is a continuous composite scale that represents the student’s confidence in science regarding tests, textbooks, skills and assignments. The values for this variable ranged from -2.91 to 1.83, with a mean of -0.00, and a standard deviation of 1.00.

Sex. The student’s sex was coded 1 for male, and 2 for female. The mean was 1.50, with a standard deviation of 0.500, which indicates a relatively equal distribution of males (50%) and females (50%) in this study.

White. Students that self-identified as White were coded as 1. This binary variable had a mean of 0.74, which indicates the weighted sample population is 74%.

Hispanic. Students that self-identified as Hispanic, Latino, or Latina were coded 1. This binary variable had a mean of 0.22, which indicates the weighted sample population is 22%.

African American. Students that self-identified as African American or African American were coded “1”. This binary variable had a mean of 0.20, which indicates the weighted sample population is 20%.

Asian. Students that self-identified as Asian were coded “1”. This binary variable had a mean of 0.06, which indicates the weighted sample population is 6%.

Hawaiian/Pacific Islander. Students that self-identified as Hawaiian/Pacific Islander were coded “1”. This binary variable had a mean of 0.03, which indicates weighted sample population is 3%.
American Indian/Native Alaskan. Students that self-identified as Asian were coded “1”. This binary variable had a mean of 0.10, which indicates the weighted sample population is 10%.

Outcome expectations. Outcome expectations is a continuous composite variable created from student responses to whether or not participating in science/math related activities would have a negative effect on them. This variable was coded on a 4-point Likert scale (1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree). This variable had a mean of 2.93, with a standard deviation of 0.57.

Outreach programs - none. Outreach programs is a composite categorical variable of student responses to whether or not they participated in MESA, Upward Bound, Avid, Talent Search, or Gear Up. The weighted mean was 0.87 indicating that 87% of the students did not participate in any of the outreach programs listed.

Outreach programs – at least one. The weighted mean was 0.09 indicating that 9% of the students participated in at least one outreach program listed.

Outreach programs – more than one. The mean was 0.04 indicating that 4% of the students did not participate in any of the outreach programs listed.

Parental support - none. Parental support is a composite categorical variable of parent responses to whether or not they took their child to a science museum, science camp, science fair, helped with a science project, or had a discussion about science. The weighted mean was 0.16 indicating that 16% of the parents did not engage in the types of support listed.
**Parental support – at least one.** The weighted mean was 0.28 indicating that 28% of the parents participated in at least one activity.

**Parental support – more than one.** The weighted mean was 0.56 indicating that 56% of the parents participated in more than one activity.

**STEM Career Intent by age 30.** Student responses to whether or not they intend to pursue a STEM career by the age of 30 were coded “0” for no, and “1” for yes. A mean of 0.16 indicates that 16% of the sample had this intent.

**Extracurricular science learning experiences – none.** This variable represented students who responded that they did not participate in any of the extracurricular science activities included in this composite variable (science club, science competition, science camp, science tutoring, and science museum visit). It was coded “0” for no, and “1” for yes. A mean of 0.74 indicates that 74% of the students had no participation of this type.

**Extracurricular science learning experiences – at least one.** This variable represented students who responded that they participated in at least one of the extracurricular science activities included in this composite variable (science club, science competition, science camp, science tutoring, and science museum visit). It was coded “0” for no, and “1” for yes. A mean of 0.23 indicates that 23% of the students had no participation of this type.

**Extracurricular science learning experiences – more than 1.** This variable represented students who responded that they participated in more than one of the extracurricular science activities included in this composite variable (science club, science competition, science camp, science tutoring, and science museum visit). It was coded “0” for
no, and “1” for yes. A mean of 0.03 indicates that 3% of the students participated in more than one of these activities.

**Parent science homework self-efficacy—very confident.** This variable represents parents who responded that they were very confident in helping their child with science homework. It was coded “0” for no, and “1” for yes. The mean was 0.38 which indicates 38% of the parents responded that they were very confident.

**Parent science homework self-efficacy—somewhat confident.** This variable represents parents who responded that they were somewhat confident in helping their child with science homework. It was coded “0” for no, and “1” for yes. The mean was 0.47 which indicates 47% of the parents responded that they were somewhat confident.

**Parent science homework self-efficacy—not at all confident.** This variable represents parents who responded that they were not at all confident in helping their child with science homework. It was coded “0” for no, and “1” for yes. The mean was 0.15 which indicates 15% of the parents responded that they were not confident at all.

**Level 2 Variables (School)**

**Percent free/reduced lunch.** This variable represents the percentage of the student body receiving free or reduced lunch. The values ranged from 0 to 100, with a weighted mean of 39.29.

**Percent ELL.** This variable represents the percentage of students in schools that were English Language Learners. The values ranged from 0 to 76, with a weighted mean of 6.27, which indicates that ~6% of the students in the schools were English Language Learners.
**Percent White.** This variable represents the percentage of students in schools that were White. The values ranged from 0 to 100, with a weighted mean of 59.73, which indicates an average of 60% of students in the schools were classified as White.

**Locale 1 – city.** This variable represents those schools that were classified as being located in the city. It was coded “0” for no, and “1” for yes. The weighted mean was 0.32 which indicates 32% of schools were classified as city or urban.

**Locale 2 – suburb.** This variable represents those schools that were classified as being located in the suburbs. It was coded “0” for no, and “1” for yes. The weighted mean was 0.33 indicating that 33% of the schools were classified as suburban.

**Locale 3 – town.** This variable represents those schools that were classified as being located in a town. It was coded “0” for no, and “1” for yes. The weighted mean was 0.13 indicating that 13% of the schools were classified as in a town.

**Locale 4 – rural.** This variable represents those schools that were classified as being located in a rural area. It was coded “0” for no, and “1” for yes. The weighted mean was 0.23 indicating that 23% of schools were classified as rural.

**School Type 1 – public.** This variable represents those schools that were classified as being public with no religious affiliation. It was coded “0” for no, and “1” for yes. The mean was 0.93 indicating that 93% of the schools were classified as public.

**School Type 2 – Catholic.** This variable represents those schools that were classified as being Catholic. It was coded “0” for no, and “1” for yes. The weighted mean was 0.04 indicating that 4% of schools were classified as Catholic.
School Type 3 – other private. This variable represents those schools that were classified as private with no religious affiliation. It was coded “0” for no, and “1” for yes. The weighted mean was 0.03 indicating that 3% of schools were classified as other private.

Predicting Student Science Self-Efficacy

The results for the student weighted data predicting student science self-efficacy are presented in Table 4. The student weighted data is generalized to the total student population in the 9th grade throughout the country so that trends and patterns can be observed based on the inferences from the sample.
# Table 4

**Student level and School Level Predictors of Student Science Self-Efficacy-Weighted**

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Null</th>
<th>Level 1</th>
<th>Level 1 w/Int</th>
<th>Levels 1 &amp; 2</th>
<th>Levels 1 &amp; 2 w/Int</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>Std Error</td>
<td>β</td>
<td>Std Error</td>
<td>β</td>
</tr>
<tr>
<td><strong>Intercepts</strong></td>
<td>-0.00</td>
<td>0.01</td>
<td>0.37***</td>
<td>0.08</td>
<td>0.34***</td>
</tr>
<tr>
<td>SES</td>
<td>0.03</td>
<td>0.03</td>
<td>-0.06</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Science Identity</td>
<td>0.44***</td>
<td>0.01</td>
<td>0.44***</td>
<td>0.01</td>
<td>0.44***</td>
</tr>
<tr>
<td>Sex</td>
<td>-0.18***</td>
<td>0.02</td>
<td>-0.11</td>
<td>0.06</td>
<td>-0.17***</td>
</tr>
<tr>
<td>Hispanic</td>
<td>-0.07</td>
<td>0.04</td>
<td>-0.05</td>
<td>0.04</td>
<td>-0.08</td>
</tr>
<tr>
<td>African American</td>
<td>0.08*</td>
<td>0.04</td>
<td>0.09*</td>
<td>0.04</td>
<td>0.09*</td>
</tr>
<tr>
<td>Asian</td>
<td>0.03</td>
<td>0.06</td>
<td>0.03</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>Hawaiian/Pacific Islander</td>
<td>-0.08</td>
<td>0.09</td>
<td>-0.08</td>
<td>0.11</td>
<td>-0.10</td>
</tr>
<tr>
<td>American Indian/Native Alaskan</td>
<td>0.03</td>
<td>0.04</td>
<td>0.03</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Outreach Programs - none</td>
<td>-0.09</td>
<td>0.04</td>
<td>-0.09*</td>
<td>0.04</td>
<td>-0.09*</td>
</tr>
<tr>
<td>Outreach Programs – &gt; 1</td>
<td>-0.06</td>
<td>0.10</td>
<td>-0.06</td>
<td>0.10</td>
<td>-0.05</td>
</tr>
<tr>
<td>Parental Support - none</td>
<td>-0.03</td>
<td>0.05</td>
<td>-0.10</td>
<td>0.08</td>
<td>-0.02</td>
</tr>
<tr>
<td>Parental Support - &gt; 1</td>
<td>0.04</td>
<td>0.03</td>
<td>0.11</td>
<td>0.06</td>
<td>0.04</td>
</tr>
<tr>
<td>Parent HWSE(VC)</td>
<td>0.12**</td>
<td>0.04</td>
<td>0.11*</td>
<td>0.04</td>
<td>0.11*</td>
</tr>
<tr>
<td>Parent HWSE(SC)</td>
<td>0.09*</td>
<td>0.04</td>
<td>0.09*</td>
<td>0.04</td>
<td>0.10*</td>
</tr>
<tr>
<td>ExtraCurrSci (0)</td>
<td>-0.13***</td>
<td>0.04</td>
<td>-0.13***</td>
<td>0.04</td>
<td>-0.13***</td>
</tr>
<tr>
<td>ExtraCurrSci (2)</td>
<td>0.16*</td>
<td>0.06</td>
<td>0.16*</td>
<td>0.06</td>
<td>0.16*</td>
</tr>
<tr>
<td>Sex X ParSup</td>
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<td>0.04</td>
<td>-0.05</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Sex X SES</td>
<td>0.06**</td>
<td>0.02</td>
<td>0.05</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>

**Level 2 (School)**

| % Free Lunch | -0.00 | 0.00 | -0.00 | 0.00 |
| % ELL | 0.00 | 0.00 | 0.00 | 0.00 |
| % White | 0.00 | 0.00 | 0.00 | 0.00 |
Table 4 cont’d

<table>
<thead>
<tr>
<th>Locale 1 - City</th>
<th>0.06</th>
<th>0.04</th>
<th>0.06</th>
<th>0.04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locale 3 - Town</td>
<td>-0.09</td>
<td>0.05</td>
<td>-0.08</td>
<td>0.05</td>
</tr>
<tr>
<td>Locale 4 - Rural</td>
<td>-0.06</td>
<td>0.04</td>
<td>-0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>School Type - Catholic</td>
<td>-0.04</td>
<td>0.06</td>
<td>-0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>School Type – Other Private</td>
<td>-0.08</td>
<td>0.07</td>
<td>-0.08</td>
<td>0.07</td>
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</table>

<table>
<thead>
<tr>
<th>Parameters</th>
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<th>0.06</th>
<th>0.06</th>
<th>0.06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviance</td>
<td>44306.68</td>
<td>27290.42***</td>
<td>27268.35***</td>
<td>27256.22***</td>
</tr>
<tr>
<td>Variance (Int)</td>
<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Variance -res</td>
<td>0.94</td>
<td>0.69</td>
<td>0.69</td>
<td>0.69</td>
</tr>
<tr>
<td>ICC</td>
<td>0.05</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Pseudo R²-res</td>
<td>0.27</td>
<td>0.27</td>
<td>0.27</td>
<td>0.27</td>
</tr>
<tr>
<td>χ² (DF)</td>
<td>1686.76***(850)</td>
<td>1864.25***(840)</td>
<td>1822.50***(840)</td>
<td>1789.25***(840)</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01, ***p < .001

Parent HWSEVC = Parental Science Homework Self Efficacy (Very Confident)
Parent HWSESC = Parental Science Homework Self Efficacy (Somewhat Confident)
ExtraCurrSci (0) = Extracurricular science activities (none)
ExtraCurrSci (2) = Extracurricular science activities (more than 1)
Null Model

The null model, also called the intercept-only model, predicted the level-1 intercept of Science Self-Efficacy scores as a random effect of school characteristics. The level-1 intercept was predicted as a function of the level-2 intercept and level-2 error term. Since there were no predictors in the null model, it controlled for all level-1 and level-2 effects which included individual student factors and school factors.

As shown in Table 4, the variance parameters indicated a between the schools variance of 5% and a within the schools variance of 94%. The interclass correlation (ICC) was also calculated. The ICC is a statistic that represents the proportion of total variance that is between groups or at level 2. It is calculated using the formula: $\sigma^2_a / (\sigma^2_a + \sigma^2_e)$ where $\sigma^2_a$ is the variance between groups and $\sigma^2_e$ is the variance within groups (Stannish & Taylor, 1983). The ICC for the null model was 0.05, which indicates that 5% of the model variance in student science self-efficacy is explained by school level factors.

Random Effects Model

The random effects model fully considered all level-1 variables while controlling level-2 variables, which allowed for comparison to the null model. This model suggests that once student level predictors are included in the model, the average student science self-efficacy score was 0.37 at $p < .001$, but now the ICC indicates that 8% of the variance is between the schools, relative to the total variance. The parameters indicated a between the schools variance of 6% and a within the schools variance of 69%. In addition, the pseudo $R^2$ was calculated. Pseudo $R^2$ is a statistic that represents the amount of variance explained by each model in comparison to the null. It is calculated using Snijders and Bosker’s (1994)
A residual Pseudo $R^2$ of 0.27 was obtained, which indicates that 27% of the model variance was explained by level 1 (student) characteristics.

The analysis indicates that science identity ($\beta = 0.44, p < .001$) and self-identified as African American ($\beta = 0.08, p < .05$) were positively related to student science self-efficacy. In addition, students whose parents were very confident ($\beta = 0.12, p < .01$) or somewhat confident ($\beta = 0.09, p < .01$) in helping their child with science homework (in contrast to not at all confident), and students who participated in more than one extracurricular science activity ($\beta = 0.16, p < .05$) in contrast to participating in at least one activity, also had a positive relationship to student science self-efficacy. Being female ($\beta = -0.18, p < .001$) and not participating in any extracurricular science activities ($\beta = -0.13, p < .001$), compared to participating in at least one, were the only two variables with a statistically significant negative relationship to science self-efficacy. SES, being Hispanic, Asian, Hawaiian/Pacific Islander, American Indian/Native Alaskan, and participating in outreach programs did not have a statistically significant relationship to student science self-efficacy.

The deviance was also calculated for each model. The deviance is a statistic equal to $-2 \text{ log likelihood ratio}$ and measures the fit across models predicting the same outcome variable. The deviance value should decrease at least by half if the model’s fit is increasing once predictors are added, indicating that the predictive power increases over the null model (Nelder & Wedderburn, 1972). The deviance value of 44306.68 for the null model is reduced by 39% once level 1 variables are added, which suggests that the model’s fit improves when we include student level variables.
Once the interaction terms (Sex x Parental Support) and (Sex x SES) were included in the model the β coefficient for SES goes from 0.03 to -0.06, but remains not statistically significant, suggesting SES and the interaction term (Sex X SES) are highly correlated. This interaction term is positive and statistically significant, which indicates that the relationship between SES and self-efficacy does vary by sex. Also, students who did not participate in any outreach programs is significant.

**Intercepts-as-Outcomes Model**

The intercepts-as-outcomes model included both predictors at level-1 (students) and level-2 (schools). Once the school level characteristics are included, the only major difference observed over level 1 inclusion is that the β coefficient for parental support is no longer statistically significant. As indicated by only a slight reduction in deviance and no change in the variance (Intercept) from level 1 to level 2, which represents how much of the self-efficacy is explained by the school level variables in the model, school level characteristics did not show any statistically significant relationship to student science self-efficacy.

Including interaction effects with levels 1 and 2 characteristics again reveals a sign change for SES from 0.03 to -0.05, which confirms that SES and the interaction term are likely highly correlated. Again, school level characteristics did not show any statistically significant relationship to student science self-efficacy for this model. Finally, the model indicates that the relationship between SES and parental support to self-efficacy does not vary significantly by sex. The deviance value remained relatively unchanged as level 2
variables and interaction terms were included in the model, which suggests no significant improvement in the model’s predictive power.

Predicting STEM Career Intent by Age 30

In order to determine the predictors of a binary question (yes or no) such as whether or not a student plans to major in a STEM field, hierarchical logistic regression was conducted. The results of the hierarchical logistic regression are shown in Tables 8 and 9. Table 5 shows the β coefficients and Table 6 shows the odds ratios. The odds ratio (OR) was determined and interpreted for each variable. An OR value greater than 1 is interpreted as a positive association with the outcome variable, while an OR less than 1 is interpreted as a negative association with the outcome variable. The closer the OR is to 1, the weaker the relationship between the predictor and outcome variable. The coding scheme employed to interpret the odds ratio for this analysis is shown in Table 7.
Table 5

*Student level and School Level Predictors of STEM Career Intent-Weighted* (β Coefficients)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Null</th>
<th>Level 1</th>
<th>Level 1 w/Int</th>
<th>Levels 1 and 2</th>
<th>Levels 1 and 2 w/Int</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β Coeff</td>
<td>Std Error</td>
<td>β Coeff</td>
<td>Std Error</td>
<td>β Coeff</td>
</tr>
<tr>
<td>Intercept (Student)</td>
<td>-1.6***</td>
<td>0.02</td>
<td>-0.07</td>
<td>0.19</td>
<td>-0.12</td>
</tr>
<tr>
<td>SES</td>
<td>-0.01</td>
<td>0.05</td>
<td>-0.24**</td>
<td>0.07</td>
<td>-0.00</td>
</tr>
<tr>
<td>Science Identity</td>
<td>0.46***</td>
<td>0.04</td>
<td>0.47***</td>
<td>0.04</td>
<td>0.47***</td>
</tr>
<tr>
<td>Science SE</td>
<td>0.06</td>
<td>0.04</td>
<td>0.06</td>
<td>0.04</td>
<td>0.06</td>
</tr>
<tr>
<td>Sex</td>
<td>-0.89***</td>
<td>0.07</td>
<td>-0.75***</td>
<td>0.15</td>
<td>-0.89***</td>
</tr>
<tr>
<td>Hispanic</td>
<td>-0.00</td>
<td>0.10</td>
<td>0.02</td>
<td>0.10</td>
<td>-0.02</td>
</tr>
<tr>
<td>African American</td>
<td>-0.44***</td>
<td>0.10</td>
<td>-0.42***</td>
<td>0.10</td>
<td>-0.43***</td>
</tr>
<tr>
<td>Asian</td>
<td>0.06</td>
<td>0.10</td>
<td>0.02</td>
<td>0.10</td>
<td>-0.00</td>
</tr>
<tr>
<td>Hawaiian / Pacific Islander</td>
<td>0.02</td>
<td>0.19</td>
<td>0.04</td>
<td>0.19</td>
<td>-0.03</td>
</tr>
<tr>
<td>American Indian / Native Alaskan</td>
<td>-0.14</td>
<td>0.12</td>
<td>-0.11</td>
<td>0.12</td>
<td>-0.14</td>
</tr>
<tr>
<td>Outcome Expectations</td>
<td>0.12*</td>
<td>0.06</td>
<td>0.12*</td>
<td>0.06</td>
<td>0.13*</td>
</tr>
<tr>
<td>Outreach Programs - none</td>
<td>0.07</td>
<td>0.11</td>
<td>0.04</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Outreach Programs - &gt; 1</td>
<td>-0.44</td>
<td>0.25</td>
<td>-0.42</td>
<td>0.26</td>
<td>-0.41</td>
</tr>
<tr>
<td>Parental Support - none</td>
<td>0.03</td>
<td>0.10</td>
<td>-0.12</td>
<td>0.16</td>
<td>0.06</td>
</tr>
<tr>
<td>Parental Support - &gt; 1</td>
<td>0.05</td>
<td>0.07</td>
<td>0.21</td>
<td>0.14</td>
<td>0.04</td>
</tr>
<tr>
<td>Parent science HWSE(VC)</td>
<td>-0.12</td>
<td>0.04</td>
<td>-0.14</td>
<td>0.10</td>
<td>-0.12</td>
</tr>
<tr>
<td>Parent science HWSE(SC)</td>
<td>-0.13</td>
<td>0.10</td>
<td>-0.13</td>
<td>0.10</td>
<td>-0.12</td>
</tr>
<tr>
<td>Extra Curr Sci - none</td>
<td>-0.16*</td>
<td>0.07</td>
<td>-0.14*</td>
<td>0.07</td>
<td>-0.14*</td>
</tr>
<tr>
<td>Extra Curr Sci - &gt; 1</td>
<td>-0.00</td>
<td>0.14</td>
<td>-0.03</td>
<td>0.14</td>
<td>-0.01</td>
</tr>
<tr>
<td>Sex X Par Sup</td>
<td>-0.12</td>
<td>0.09</td>
<td>-0.12</td>
<td>0.09</td>
<td>-0.12</td>
</tr>
<tr>
<td>Sex X SES</td>
<td>0.17***</td>
<td>0.04</td>
<td>-0.01</td>
<td>0.00</td>
<td>-0.01**</td>
</tr>
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</table>

Level 2 (School)

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>% Free Lunch</td>
<td>-0.01***</td>
<td>0.00</td>
<td>-0.01*</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>% ELL</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>% White</td>
<td>-0.00</td>
<td>0.00</td>
<td>-0.00</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

109
Table 5 cont’d

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Locale 1 - City</th>
<th>Locale 3 - Town</th>
<th>Locale 4 - Rural</th>
<th>School Type - Catholic</th>
<th>School Type – Other Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviance</td>
<td>36542.43</td>
<td>20892.00***</td>
<td>20875.58***</td>
<td>20850.54***</td>
<td>20844.36***</td>
</tr>
<tr>
<td>Variance (Int)</td>
<td>0.05</td>
<td>0.07</td>
<td>0.07</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>$\chi^2$ (DF)</td>
<td>946.12 (850)**</td>
<td>887.60 (840)</td>
<td>884.88 (840)</td>
<td>861.20(830)</td>
<td>860.27 (830)</td>
</tr>
</tbody>
</table>

Note: *** p < 0.001, ** p < 0.01, * p < 0.05
Table 6
Student level and School Predictors of STEM Career Intent-Weighted (Odds Ratios)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Level 1 Odds Ratio</th>
<th>Confidence Intervals at 95%</th>
<th>Levels 1&amp;2 Odds Ratio</th>
<th>Confidence Intervals At 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1 - Student</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.930</td>
<td>(0.643, 1.345)</td>
<td>0.885</td>
<td>(0.605, 1.293)</td>
</tr>
<tr>
<td>SES</td>
<td>0.992</td>
<td>(0.903, 1.091)</td>
<td>0.999</td>
<td>(0.909, 1.099)</td>
</tr>
<tr>
<td>Science Identity</td>
<td>1.582***</td>
<td>(1.461, 1.713)</td>
<td>1.595***</td>
<td>(1.472, 1.727)</td>
</tr>
<tr>
<td>Science Self Efficacy</td>
<td>1.058</td>
<td>(0.975, 1.148)</td>
<td>1.060</td>
<td>(0.976, 1.151)</td>
</tr>
<tr>
<td>Sex</td>
<td>0.412***</td>
<td>(0.362, 0.469)</td>
<td>0.410***</td>
<td>(0.360, 0.467)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.996</td>
<td>(0.823, 1.205)</td>
<td>0.980</td>
<td>(0.801, 1.201)</td>
</tr>
<tr>
<td>African American</td>
<td>0.641***</td>
<td>(0.524, 0.785)</td>
<td>0.652***</td>
<td>(0.529, 0.804)</td>
</tr>
<tr>
<td>Asian</td>
<td>1.062</td>
<td>(0.873, 1.292)</td>
<td>0.993</td>
<td>(0.814, 1.211)</td>
</tr>
<tr>
<td>Hawaiian/Pacific Islander</td>
<td>1.024</td>
<td>(0.702, 1.494)</td>
<td>0.969</td>
<td>(0.660, 1.422)</td>
</tr>
<tr>
<td>American Indian/ Native Alaskan</td>
<td>0.867</td>
<td>(0.683, 1.101)</td>
<td>0.874</td>
<td>(0.687, 1.112)</td>
</tr>
<tr>
<td>Outcome Expectations</td>
<td>1.132*</td>
<td>(1.012, 1.267)</td>
<td>1.131*</td>
<td>(1.009, 1.267)</td>
</tr>
<tr>
<td>Outreach Programs - 0</td>
<td>1.073</td>
<td>(0.851, 1.353)</td>
<td>1.050</td>
<td>(0.830, 1.328)</td>
</tr>
<tr>
<td>Outreach Programs - &gt; 1</td>
<td>0.643</td>
<td>(0.390, 1.061)</td>
<td>0.660</td>
<td>(0.402, 1.086)</td>
</tr>
<tr>
<td>Parental Support - 0</td>
<td>1.030</td>
<td>(0.841, 1.262)</td>
<td>1.064</td>
<td>(0.867, 1.305)</td>
</tr>
<tr>
<td>Parental Support - &gt; 1</td>
<td>1.053</td>
<td>(0.915, 1.212)</td>
<td>1.043</td>
<td>(0.907, 1.199)</td>
</tr>
<tr>
<td>ExtraCur(0)</td>
<td>0.850*</td>
<td>(0.742, 0.975)</td>
<td>0.867*</td>
<td>(0.755, 0.996)</td>
</tr>
<tr>
<td>ExtraCur(2)</td>
<td>0.995</td>
<td>(0.758, 1.312)</td>
<td>0.985</td>
<td>(0.747, 1.298)</td>
</tr>
<tr>
<td>ParSciHWSE(VC)</td>
<td>0.889</td>
<td>(0.732, 1.079)</td>
<td>0.884</td>
<td>(0.726, 1.076)</td>
</tr>
<tr>
<td>ParSciHWSE(SC)</td>
<td>0.882</td>
<td>(0.729, 1.068)</td>
<td>0.891</td>
<td>(0.735, 1.081)</td>
</tr>
<tr>
<td><strong>Level 2 - School</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Free Lunch</td>
<td>0.992***</td>
<td>(0.988, 0.996)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% ELL</td>
<td>1.003</td>
<td>(0.993, 1.014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% White</td>
<td>0.997</td>
<td>(0.994, 1.000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locale 1 - City</td>
<td>1.417***</td>
<td>(1.214, 1.654)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locale 3 - Town</td>
<td>0.938</td>
<td>(0.761, 1.157)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locale 4 - Rural</td>
<td>1.067</td>
<td>(0.884, 1.289)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School Type - Catholic</td>
<td>0.708**</td>
<td>(0.560, 0.896)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School Type – other</td>
<td>0.809</td>
<td>(0.628, 1.041)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 7  
*Protocol for Odds Ratio Interpretation*

<table>
<thead>
<tr>
<th>Odds Ratio Range</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 0.45</td>
<td>Strong negative (StN)</td>
</tr>
<tr>
<td>0.46 to 0.65</td>
<td>Moderately negative (MN)</td>
</tr>
<tr>
<td>0.66 to 0.99</td>
<td>Slightly negative (SlN)</td>
</tr>
<tr>
<td>1.1 to 1.35</td>
<td>Slightly positive (SIP)</td>
</tr>
<tr>
<td>1.36 to 1.49</td>
<td>Moderately positive (MP)</td>
</tr>
<tr>
<td>1.50 and greater</td>
<td>Strong positive (StP)</td>
</tr>
</tbody>
</table>

**Random Effects Model**

The random effects model fully considered all level-1 variables while controlling level-2 variables, which allowed for comparison to the null model. The results in Table 5 show that having a strong science identity ($\beta = 0.46$, $p < 0.001$, OR = 1.582) compared to none, being female compared to male ($\beta = -0.89$, $p < 0.001$, OR = 0.413), being African American compared to White ($\beta = -0.46$, $p < 0.001$, OR = 0.640), outcome expectations ($\beta = 0.13$, $p < 0.05$, OR = 1.135), and not participating in any extracurricular science activities compared to one activity ($\beta = -0.16$, $p < 0.5$, OR = 0.851) are predictors of STEM career intent by age 30. Focusing on those factors that reveal moderate to strong relationships to STEM career intent, the odds ratios shown in Table 5 indicate that science identity is a strong positive predictor of STEM career intent while sex is a strong negative predictor. These findings suggest that females, compared to males are considerably less likely to pursue a STEM career, and the students who have a positive science identity are considerably more likely to pursue a STEM career. Additionally, being African American shows a moderately negative relationship, suggesting that African American students, compared to White students, are less likely to pursue STEM careers.
Once interaction terms were included in the model, SES shows a statistically significant negative relationship to STEM career intent, which suggests that as income rises, 9th grade are less likely to report intent to pursue a STEM career. The results indicate that there is no interaction effect for sex and parental support; however the results do indicate that there is a positive interaction for sex and SES (β = 0.17, p < .001, OR = 1.185).

**Intercepts-as-Outcomes Model**

The intercepts-as-outcomes model included predictors at student and school level. Once the school level characteristics were included, only minor changes in the β coefficients (i.e., 0.1 – 0.3) of the student level predictors were observed.

For the school level characteristics, the data indicates that students in schools located in urban areas (β = 0.35 at p < 0.001, OR = 1.418) were more likely than students in the suburbs to pursue STEM careers. In contrast, students who are on free/reduced lunch (β = -0.00 at p < 0.001, OR = 0.992) and students in Catholic schools (β = -0.35 at p < 0.01 OR = 0.708) compared to public schools, are less likely to pursue STEM careers.

Once interaction terms were included, SES becomes a statistically significant predictor for STEM career intent (β = -0.17, p < .01, OR = 0.841), likely due to an issue of multicollinearity with the added interaction term. In addition, the relationship between SES and STEM career intent does vary significantly by sex (β = 0.12, p < 0.001, OR =1.13).

Overall the results showed eight statistically significant factors from the fully specified model (levels 1 and 2 with without interaction terms) that predict STEM career intent for this sample: science identity positively predicted both science self-efficacy and STEM career intent, sex negatively predicted both science self-efficacy and STEM career
intent, being Black positively predicted science self-efficacy and negatively predicted STEM career intent, extracurricular science activities (none) negatively predicted both science self-efficacy and STEM career intent, outcome expectations positively predicted STEM career intent, the percent of students on free/reduced lunch negatively predicted STEM career intent, students in schools located in urban areas positively predicted STEM career intent, and students in Catholic schools negatively predicted STEM career intent.

This chapter provided detailed descriptive statistics for each variable included in the study, along with the results for each of the analysis models that included the null, random effects, intercepts as outcomes, and fully specified model with interaction terms. The magnitude of the beta coefficients and odds ratio values were discussed. The final chapter discusses some key findings from the study, theoretical and practical implications, limitations of the study, and future directions for research.
CHAPTER V: CONCLUSIONS AND DISCUSSION

This study examined the relationship between personal, background, and contextual factors on the constructs of science self-efficacy and STEM career intent. The results are interpreted using Lent, Brown and Hackett’s (1994) social cognitive career theory (SCCT). Conclusions and implications are drawn based on findings of the study. Finally, future directions are presented.

Key Findings

A summary of the key findings based on the fully specified model that included both level 1 and 2 variables, with interaction terms are shown in Table 8.
<table>
<thead>
<tr>
<th>RQ</th>
<th>Variables</th>
<th>Science Self-Efficacy</th>
<th>STEM Career Intent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Level 1</td>
<td>Level 1 w/Int</td>
</tr>
<tr>
<td><strong>Person Inputs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1A, 3A</td>
<td>African American</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>1A, 3A</td>
<td>Hispanic</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1A, 3A</td>
<td>Asian</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1A, 3A</td>
<td>Hawaiian/Pacific Islander</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1A, 3A</td>
<td>American Indian/Native American</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1A, 3A</td>
<td>Sex</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1A, 3A</td>
<td>Science identity</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Self-efficacy</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Outcome Expectations</td>
<td>n/a</td>
<td>n/a</td>
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<td><strong>Background Affordances</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1C, 3C</td>
<td>SES</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1C, 3C</td>
<td>Parental support - none</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Parental support - &gt; 1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1C, 3C</td>
<td>Parent science homework self-efficacy—very confident</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>1C, 3C</td>
<td>Parent science homework self-efficacy—somewhat confident</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Informal Learning Experiences</strong></td>
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<tr>
<td>1B, 3B</td>
<td>Extracurricular science learning experiences – none</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1B, 3B</td>
<td>Extracurricular science learning experiences – &gt; 1</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>1B, 3B</td>
<td>Outreach programs - none</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Outreach programs - &gt; 1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>School Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2, 4</td>
<td>% free/reduced lunch</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2, 4</td>
<td>% White</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2, 4</td>
<td>% ELL</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2, 4</td>
<td>Locale - city</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
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<td>Locale - town</td>
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<td>n/a</td>
</tr>
<tr>
<td>2, 4</td>
<td>Locale - rural</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Table 8 cont’d

<p>| | | | | | | |</p>
<table>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 4</td>
<td>School type - Catholic</td>
<td>n/a</td>
<td>n/a</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2, 4</td>
<td>School type - Other private</td>
<td>n/a</td>
<td>n/a</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>5, 6</td>
<td>Sex X SES</td>
<td>n/a</td>
<td>+</td>
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a = sign or statistical significance changes across models predicting self-efficacy
b = sign or statistical significance changes across models predicting STEM career intent
+ = positive relationship, - = negative relationship, 0 = no relationship
Predicting Science Self-Efficacy

The findings related to the research questions predicting student science self-efficacy are presented below.

RQ1a. To what extent do a student’s person inputs (race, sex, science identity) predict student science self-efficacy?

The data indicated that being African American (as compared to White), and having a science identity are positively related to student science self-efficacy. In contrast, being female, compared to male is negatively related to science self-efficacy. Self-identifying as Asian, Hispanic, American Indian/Native Alaskan, or Hawaiian/Pacific Islander (as compared to White), showed no statistically significant relationship with self-efficacy.

RQ1b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict student science self-efficacy?

The data indicated that being a student who participated in more than one extracurricular science activity (science club, science competition, science fair, science museum) as compared to only one activity, was positively associated with science self-efficacy. In contrast, being a student who had no participation in these activities, compared to those participating in at least one activity, was negatively related to science self-efficacy. Not participating any outreach programs, compared to participating in at least one program, was negatively related to science self-efficacy, however participating in more than one program showed no relationship to self-efficacy.
RQ1c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict student science self-efficacy?

The results showed that parents who felt very confident or somewhat confident in helping their child with science homework (compared to not being confident at all) was positively related to self-efficacy. Parental support and SES showed no relationship to science self-efficacy.

RQ2. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, percent White students in school, percent English language learners in school, percent of students on free and reduced lunch) predict student science self-efficacy?

The data indicated that the percent of students on free/reduced lunch, White and ELL, was unrelated to self-efficacy. Schools, locales classified as towns, urban or rural areas compared to the suburbs, did not predict student science self-efficacy.

RQ5. To what extent does the relationship between background contextual affordances (SES and parental support) and science self-efficacy vary by sex?

The data indicated that the relationship between SES and science self-efficacy does vary by sex, but the relationship between parental support and self-efficacy does not vary by sex.

Predicting STEM Career Intent

The findings related to the research questions predicting STEM career intent are presented below.
RQ3a. To what extent do a student’s person inputs (race, sex, science identity) predict a student’s STEM career intent?

Being African American (OR = 0.651) compared to White, and being female (OR = 0.410) compared to male were negative predictors of STEM career intent. Self identifying as Hispanic, Asian, Hawaiian/Pacific Islander, and American Indian/Native American (compared to White) was not related to career intent. Having a science identity (OR = 1.595) showed a positive relationship to career intent. This means that African American students’ STEM career intent is 35% less than White students and that females’ STEM career intent is 59% less than males. Also, students who have a strong science identity are 60% more likely to intend to pursue STEM careers.

RQ3b. To what extent do a student’s informal learning experiences (participation in outreach programs and extra-curricular science activities) predict a student’s STEM career intent?

The data indicated that students not participating in any extracurricular science activities (compared to at least one activity) was negatively related to STEM career intent, and participating in more than one extracurricular science activity (compared to at least one activity) showed no relationship to career intent. Also, participation in outreach programs (compared to no participation) showed no relationship to career intent. This means that students who did not participate in any activities were 13% less likely than students who participated in at least one activity to intend to pursue a STEM career. Also, outreach programs showed no relationship to STEM career intent.
RQ3c. To what extent do a student’s background contextual affordances (parental support, parent science homework self-efficacy, SES) predict a student’s STEM career intent?

The data indicated that having parental support (compared to no parental support), parents who were very confident or somewhat confident in helping with science homework (compared to not confident at all), SES, and self-efficacy showed no relationship to STEM career intent. Also, while SES showed no relationship with self-efficacy in the random effects and intercepts as outcomes models without interaction terms. It did show a negative relationship at level 1 with interaction terms, which suggests that SES may be highly correlated with the interaction term (SES x sex).

RQ4. Controlling for student level factors, to what extent do contextual factors proximal to choice behavior (school type, school locale, percent White students in school, percent English language learners in school, percent of students on free and reduced lunch) predict a student’s STEM career intent?

The data indicated that the percent of students on free or reduced lunch (OR = 0.992) and students schools designated as Catholic (OR = 0.708), compared to public schools, were negative predictors of STEM career intent. Students in schools located in the city (OR = 1.418) compared to the suburbs were more likely to intend to pursue STEM careers. In contrast, students in urban schools are 42% more likely, than those in suburban schools, to intend to pursue a STEM career.

RQ6. To what extent does the relationship between background contextual affordances (SES and parental support) and STEM career intent vary by sex?
The data indicated that the relationship between SES and STEM career intent does vary by sex, but that the relationship between parental support and science self-efficacy and STEM career intent does not vary by sex. Again, because SES may be highly correlated to the interaction term (SES x sex), SES becomes statistically significant in the model.

**Theoretical Implications**

**Race, Sex, Identity, and Informal Science**

Overall, the data show that the person inputs of science identity (seeing yourself or others seeing you as a science person), sex, and informal learning experiences (participation in more than one) are predictors of student science self-efficacy, which is consistent with Lent, Brown and Hackett’s (1994) SCCT model. This study indicated that science identity is a key construct that predicted both science self-efficacy and STEM career intent. This finding is consistent with previous literature that suggests having a science identity can help students “see” themselves in science (Carlone & Johnson, 2007) and relate to science careers. Furthermore, the study indicates the science identity construct, developed by Carlone and Johnson (2007) may be a useful lens examine both science self-efficacy and STEM career intent, along with SCCT. The science identity construct is different from the concept of self-efficacy in that self-efficacy refers to an internalized view or belief. Whereas identity, is framed in the social experience and involves the individual’s position or membership in society. This construct is composed of three factors: performance, recognition and confidence. Perhaps by examining some of the sub categories of science identity, we can better tailor teaching and learning on a broader scale. The person input of race only showed a relationship for African American students. The other race/ethnicity categories were not
related to self-efficacy or career intent, as compared to their White counterparts, which is inconsistent with Lent, Brown and Hackett’s (1994) SCCT model. Prior literature also suggests underrepresented students who self identity as Hispanic, American Indian/Native American, and Hawaiian/Pacific Islander have lower science self-efficacy and lower STEM career intent compared to White students (e.g., Navarro, Flores & Worthington, 2007). Furthermore, the data indicate that while being African American is a positive predictor for science self-efficacy, it is a negative predictor for STEM career intent. These findings suggest that for African American students, confidence in STEM, as measured by the science self-efficacy scale for this study, does not necessarily translate to STEM career intent. This suggests that there are factors other than science self-efficacy, such as interest, understanding possible STEM career options, and knowing someone in a STEM field, that may influence career intent for this demographic.

This may also be the case because this study considers a sample of 9th graders. It might be different if we examined students in middle school. Moreover, this contradiction may be due to the fact that much of SCCT is based on college-level data, and there may be key differences in the extent to which race/ethnicity, and other variables (as discussed in the next few paragraphs) predict self-efficacy and STEM career intent. Another plausible explanation is that perhaps efforts to broaden the STEM pipeline are effective, and these data reflect this change. Lastly, there may be subcategories within these groups such as minority assimilation theories and critical race constructs (Fouad and Byars-Winston, 2005) that reveal that race/ethnicity does play a role in science self-efficacy and STEM career intent, but is not evident in aggregated data.
The negative association between not participating in extracurricular science activities and science self-efficacy lends support for the positive influence of these types of experiences on self-efficacy. Also, the negative relationship between sex and science self-efficacy, and sex and STEM career intent, aligns with previous literature showing that females, on average, have lower science self-efficacy and STEM career intent than males (Blickenstaff, 2005). This finding reiterates that even with all of the targeted outreach efforts over the last two decades to encourage girls in STEM, they still lack confidence in this area. Another interesting finding is that while parental confidence in helping with science homework and participating in extracurricular activities were related to self-efficacy, they were not related to STEM career intent. This may indicate that support structures other than those within the family such as career networks, role models, and mentoring (Quimby & DeSantis, 2006) may play an important role on STEM career intent; however, these variables were not available in HSLS:09. Also, students who did not participate in any outreach programs was negatively related to science self-efficacy but showed no relationship to STEM career intent suggesting that the negative effect from not participating outweighs any positive gains from participation. It also may suggest that the type of outreach program and duration of participation may play in role in predicting self-efficacy and STEM career intent. All of the programs included in the model, except for MESA, were college readiness programs that did not have a specific science or math related focus. That is, sufficient variation in the quality of the programs may show that these programs have no relationship with career intent and self-efficacy because they were analyzed in aggregate. While parental support, as measured on the student survey, did not show a relationship to science self-efficacy, parents
who were confident or somewhat confident in helping their child with science homework was positively related to science self-efficacy, which suggests that educators and policy makers should investigate more ways to aid and assist parents with their confidence in science, perhaps through workshops and seminars. This also suggests other methods to assess parental support should be included in the model, such as whether or not the parent has a science/math background and parent involvement in their child’s school.

**School Characteristics**

Additionally, it is interesting to note that school level variables were not predictors of science self-efficacy, but some of these factors were predictors of STEM career intent. This does not suggest that level 2 variables that describe school characteristics are not important to the model, however, it does suggest that there may be other school level variables that should be included in the model in order to explain more of the variance in science self-efficacy and STEM career intent such as whether or not the school has a science/math focus, whether or not the school hosts science related activities, whether or not the school offers advanced placement (AP) courses in math and science, the percent of students that enroll in math and science AP courses, and finally, the percent of science teachers that have a science or math background. Additionally, qualitative analysis of school settings may provide insight about how and why contextual variables are important to students’ career aspirations, such as science teaching strategies and interactions between the students and the science teacher. However, given that the null model indicated that the variance at the school level was small, we should not anticipate that school characteristics will explain much of the variance in self-efficacy. Furthermore, including teacher level variables such as the quality and training of the
science teacher, the number of years of teaching, and science teacher self-efficacy may help to explain more of the variance in both constructs. Teacher level data was not included in this study because the students were questioned at the beginning of their 9th grade year and it was hypothesized that teacher influences would not be prominent at that time. Finally, the positive relationship between outcome expectations, which is a key motivation construct in Lent, Brown & Hackett’s (1994) SCCT model, and STEM career intent suggests career intent is shaped by 9th grade students’ views of the impact that participating in math/science related tasks has on their social lives and interactions with peers.

Whereas being in a school with a high percent of students on free/reduced lunch is a predictor of career intent, being a low income student is not a predictor of career intent. These findings point out that SES does not predict self-efficacy and career intent, which contradicts Lent, Brown & Hackett’s (1994) SCCT model and other research (Ma, 2009). If we presume that the extant literature is correct in concluding that low income students are underrepresented in STEM careers, then there are two plausible explanations. STEM career intent may not be a good predictor of actual STEM career choice for all students because some students may lack career awareness. For example, a student from a low income background with limited exposure to the career may aspire to a STEM profession, but not have the knowledge, skills, dispositions, or supports to pursue the career. Another plausible explanation is that these data are from students beginning high school. Perhaps, SES is playing out before, during, or after high school. Finally, students in urban schools positively predicted STEM career intent, which may suggest that schools in areas with large populations may have access to more science and math related resources and STEM focused
initiatives (Tobin, 2008). Because urban areas tend to have large populations of minority students, urban areas have been the focus of much work on reform-based science teaching and learning practices targeted at improving student attitudes about science and increasing STEM career intent of underrepresented groups (Denso, Avery & Schell, 2010). The findings for this study related to the school level variable of urban locale, may be in some part, due to this targeted effort.

**Practical Implications**

These finding suggest that science educators, policy makers, and program leaders should incorporate more strategies that foster science identity by exposing students to hands-on and inquiry-based science, exposing them to scientific terminology and equipment, and exposing students to the real world applications of the science that they learn in the classroom. Several of these strategies for fostering science identity are accomplished outside of the formal classroom and makes the case for science educators to collaborate with informal science teachers and centers. Informal science centers have resources and equipment purchased through grant funds, that teachers in the formals setting cannot afford or do not have access to. Also, since many of the informal science centers are located on college and university campuses, students who participate in informal science experiences also have a chance to interact with scientists on campus. The literature suggests that females tend to have fewer hands-on experiences with science in and out of school (Jones & Howe, 2000) as well as lower confidence in science (Blickenstaff, 2005). Since, as the results indicate, being a female is still related to having less self-efficacy or less likely to pursue a STEM career, more efforts need to be targeted at females to increase their confidence in
Science and STEM career intent. Some strategies that show promise in encouraging females in science are through role models, mentors and seeing other females practice science and succeed in STEM fields (Packard, 2008). Furthermore, this study found that parents who were very confident or somewhat confident in helping their child with science homework was a positive predictor of science self-efficacy. Thus, educators should consider working with parents to aid them in encouraging their children in STEM related subjects since parental support, especially in STEM related subjects is important to student attitudes about science (Patall, Cooper & Robinson, 2008). Finally, the underlying factors involving the role of science self-efficacy and other factors in STEM career intent for African American students needs to be considered when designing science instruction, such as culturally relevant science education and addressing possible barriers and challenges that these students may see with regards to pursuing a STEM career.

Limitations

These data were limited to students entering their 9th grade year. Examining students at the middle school level, where much of the STEM exposure and science education reform is targeted, may have provided different results. These data do not capture changes in science self-efficacy and STEM career intent over time, which may provide more insight into the trajectories involved during the STEM career choice process as well as the development of science self-efficacy. Additionally, the data do not include measures of what is happening in the classroom, such as science teaching strategies. Finally, while the data does include questions about participation in some targeted outreach programs such as Upward Bound and whether or not students participate in school related and extracurricular science activities, it
lacks a measure of the quality of these experiences, which may influence the outcome variables of interest.

**Future Directions for Research**

The variance for the models including both student and school levels indicated that only 27% of the variability in predicting science self-efficacy was explained by student level differences. This suggests that additional factors need to be added to the model to account for more of the variance. Other school level variables may be related to science self-efficacy, such as the type and quality of science related instruction, the number of advanced level math and science courses as well as whether or not the schools participate in science related outreach activities may need to be included in further studies. Also, since interest is a key predictor of career intent based on the SCCT model, this construct should be examined in future studies. Since only students entering their 9th grade were studied, follow-up data on the students may provide more insight into their science self-efficacy and career aspirations over time and to what extent the relationship between the factors used in these models and science self-efficacy and STEM career intent vary by student grade level. Finally, while this study focused on direct effects of the variables’ relationship to science self-efficacy and STEM career intent, performing mediation analyses would capture the indirect relationships. Preliminary results showed that some of the variables were partially mediated by learning experience such as science identity and being Black, while some factors did not mediate learning experiences such as being Hispanic and SES. A further investigation of the possible mediators in the SCCT model (Lent, Brown, & Hackett, 1994) may shed additional insight into the interaction of these variables with science self-efficacy and STEM career intent.
Summary

This study was conducted in response to the growing concern about the lack of U.S. students majoring in STEM fields and pursuing STEM careers (NSF, 2013). In order for the U.S to compete in a global economy that is increasingly technologically-based, a skilled STEM workforce is a necessity (National Academies, 2010). Understanding the factors that encourage confidence in science and intent to pursue science related careers remains a national mandate. Using data from a nationally representative sample of 21,440 students from 940 schools, the High School Longitudinal Study of 2009 (HSLS:09), this study provided insight into the factors that predict science self-efficacy and STEM career intent. Guided by Lent, Brown & Hackett’s (1994) Social Cognitive Career Theory (SCCT), both student level and school factors were examined. The findings indicated that the personal inputs of being African American, female, and having a science identity predicted both science self-efficacy and STEM career intent. Participating in no extracurricular informal learning experiences predicted both science self-efficacy and STEM career intent, while participating in more than one extracurricular learning experience only predicted self-efficacy. Background contextual affordances such as socioeconomic status had no relationship to either science self-efficacy or STEM career intent. Parents who were very confident and somewhat confident in helping their child with science homework predicted science self-efficacy, but showed no relationship to STEM career intent. None of the school level variables predicted science self-efficacy, but the percent of students on free/reduced lunch, students in schools located in the city, and students in Catholic schools predicted STEM career intent. Finally, the relationship between contextual affordances (SES and
parental support) and science self-efficacy and STEM career intent did vary by sex for both outcome variables regarding socioeconomic status, but not regarding parental support.

Several implications arose from this study. First, science identity is a very useful construct that can be used to further examine science self-efficacy and STEM career intent. Based on this study’s findings, educators and policy makers should seek ways to help foster student science identity. Second, efforts to encourage girls in STEM have not been successful on a large scale and more strategies need to be explored. Third, this study makes the case for continued involvement in informal science experiences that provide students a chance to explore science at their own pace in a nonevaluative environment. Finally, while race/ethnicity has traditionally been a predictor of science self-efficacy and STEM career intent, this study suggests that there may be subcategories within race/ethnicity such as cultural perspective and additional constructs such as critical race theories that may shed light on the nuisances at play; especially in the case of students who self-identify as African American.
REFERENCES


National Science Foundation, National Center for Science and Engineering Statistics (NCSES), Survey of earned doctorates, S&E Doctorate Awards. Doctorate Recipients


